TP 6005E

# HANGRAIL LIFT SYSTEM

## AN EVALUATION OF THE FFG GLEITLIFT SYSTEM FOR VEHICLE BOARDING AND DEBOARDING OF DISABLED PERSONS

**Prepared for**

## TRANSPORTATION DEVELOPMENT CENTRE

**by**

**DeLCan**

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# Hangrail Lift System: An Evaluation of the FFG Gleitlift System for Vehicle Boarding and Deboarding of Disabled Persons

by

Peter Kaulback
DeLCan
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Prepared
for

Transportation Development Centre
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"The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada."

## PROJECT TEAM

This project was undertaken prinicipally by Peter Kaulback who undertook all the field research and analysis, supported by Rob Orchin. Additional assistance was provided by Uwe Rutenberg, President of Rutenberg Design Inc. and Tom Geehan, President, TransVision Consultants Ltd.

Wendy Davidson provided support services.


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17. Abstract

This report presents a comprehensive description of the Hangrail Lift System developed by Fahrzeugwerkstatten Falkenried GmbH, in Hamburg, West Germany. The system enables disabled persons to rapidly board and exit from a large bus by means of an inclined rail from which the wheelchair and occupant are suspended, utilizing a special hanger. A continuous chain running within the rail moves the hanger into or out of the vehicle. The hanger system also incorporates a wheelchair securement system in the vehicle and an emergency exit system. The same basic principle is utilized in a hangrail lift system for smaller collector vehicles.

The components of the system are described along with the operation and an evaluation of the applicability of this type of vehicle access and egress system to Canadian conditions.

The hangrail system solves two major problems in transportation of the handicapped - the long loading and unloading time required where a large number of passengers are involved, and the limited capacity of vehicles due to the space requirements of conventional wheelchairs. The system, however, is not without its drawbacks, the principal one being that passengers using the mobile seat system cannot move themselves when outside the vehicle. The hangrail system is a major advance in transportation for the handicapped and the system should be promoted and subsequently introduced, in an appropriate milieu, into Canada.


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17. Résumé


Ce rapport décrit le système d'embarquement pour personnes en fauteuil roulant, étudié par la firme allemande Fahrzeugwerkstatten Falkenried GmbH de Hambourg (RFA). Ce système équipant un autocar ou une fourgonnette de transport semi-collectif permet un déplacement rapide des passagers grâce à un rail incliné où circule une chaîne sans fin à laquelle sont accrochés les fauteuils roulants par l'intermédiaire d'une perche de forme spéciale. Ce système comporte, en outre, un dispositif d'immobilisation et d'évacuation rapides.

Le rapport décrit les composants du système et leur fonctionnement et en fait l'évaluation dans l'optique de leur utilisation éventuelle au Canada.

Ce système apporte une solution ingénieuse aux deux grands problèmes dans le transport des handicapés: les temps de déplacement trop longs lorsque le nombre des passagers est élevé et la perte d'espace intérieur due à l'encombrement des fauteuils roulants classiques. Il n'est toutefois pas sans inconvénient, le plus grave étant que les personnes utilisant le fauteuil spécial prévu n'ont aucun moyen de se propulser par elles-mêmes, une fois hors du véhicule. Néanmoins, le système constitue un progrès intéressant et mérite d'être introduit au Canada pour une clientèle bien définie.


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# 1. INTRODUCTION

The problems associated with the loading and unloading of wheelchairs into and out of vehicles are well documented. Modal transfer is a major difficulty in the efficient implementation of transportation services for handicapped persons. The magnitude of the problem increases substantially when large numbers of wheelchair passengers are to be accommodated. Currently the most commonly used means of vehicle access and egress is the wheelchair lift. The lift may be stowed either inside the vehicle or externally. The lift is often unsafe and may be prone to mechanical failure. Operation of the lift is time consuming and a complete operating cycle is required for each passenger. This contributes to low vehicle productivity which, due to the considerable costs involved, may make the entire transportation operation economically unviable. Furthermore, the internally stowed lift takes up space within the vehicle and may also be a safety hazard.

In 1983 a unique means for loading and unloading large numbers of wheelchairs to and from a transit vehicle came to the attention of Peter Kaulback of DeLCan. The system, the FFG Hangrail Lift System, was designed and manufactured in West Germany and is currently in limited use in that country. The system purports to overcome many of the problems inherent with the use of conventional wheelchair lifts.

DeLCan, in association with others, proposed to the Transportation Development Centre of Transport Canada, that an evaluation of this technology was worthwhile. An on-site evaluation is less expensive and can be more rapidly completed than importing the technology and arranging for demonstration and subsequent evaluation in Canada. The former approach was recommended and approval was obtained to conduct this research project examining vehicles in use.

## 1.1 Hangrail System; Background

In many countries, the mobility of the handicapped has been greatly increased in recent years by the introduction of special transport services for

recreational and leisure activities. This general rise in the level of mobility has led to an increasing number of handicapped passengers taking advantage of these services and to an increase in trip frequency. However, transport services to schools and rehabilitation centres must adapt themselves to the changing conditions caused not only by the growth in the number of such institutions, but also by structural changes, such as centralization. In Germany it was noted that there was a marked increase in the numbers of long-distance journeys and especially day-trips and outings to nearby recreational areas, and journeys to sporting activities. Suitable vehicles with adequate seating capacity are commonly not readily available.

Significant developments have been made in Germany, as well as many other countries, in vehicles intended for the transportation of handicapped persons. The Berlin (West) Telebus program, sponsored by the Federal Ministry for Research and Technology (BMFT) is world renowned. This program, and many others, do not, however, address the requirements of groups of handicapped persons requiring transportation for long distances. Little development has been undertaken in the field of vehicle technology appropriate to these requirements. Developments such as kneeling suspension which are most effective in reducing boarding and alighting times are not appropriate for larger vehicles intended principally for highway use.

Currently the vehicles available for long distance transportation are either modified coaches (such as the Kässbohrer model) which are very expensive, modified school buses equipped with lifts, or smaller vehicles such as mini-vans. The use of a large vehicle offers substantial benefits in terms of efficiency, however these benefits can only be attained if a suitable access and egress means is available. Boarding and exiting time must be reduced to a minimum in order that excessive inconvenience and time-related costs are not incurred. Conventional lifts are inappropriate for application with large numbers of wheelchair passengers. Although such lifts offer many advantages over other access means, such as telescopic ramps, their long cycle times and their unsuitability for use as a means of exit in case of an emergency, clearly limit their usefulness, especially in larger vehicles.

The unavailability of a suitable access and egress means for larger buses was noted by Hilmar Feutlinske of FFG. Herr Feutlinske has for many years been involved in transit vehicle development and had a major role in the Berlin Telebus program. Herr Feutlinske determined to design and produce an improved means for loading and unloading wheelchairs into vehicles - hence the development of the FFG Hangrail Lift System. The improvements envisaged by Herr Feutlinske were not only limited to the means of access and egress. He also noted that conventional wheelchairs take up a large space within a vehicle. If the space requirement of each individual could be reduced the carrying capacity of the bus could be increased, leading to improvements in efficiency and cost-effectiveness. A modified seating system has consequently also been developed.

It was also noted that the basic concept of the Hangrail System could also be used on smaller vehicles. A system has been designed for such vehicles and is also in use in Achern.

This report will examine the following specific features of the FFG Hangrail Lift System:

a) the Hangrail Lift System for access/egress to/from large vehicle by wheelchair passengers;

b) the special mobile seat compatible with the Hangrail Lift System and designed to increase utilization of space within the large or small vehicle;

c) the specially designed converter hanger for use with conventional wheelchairs enabling them to use the Hangrail Lift System;

d) the emergency egress system for the large bus;

e) the access/egress system developed for the small paratransit vehicles, currently used as 'collectors' for the large vehicle, and;

f) a special non-mobile vehicle seat (either bench type or single seat) designed for use in vehicles that are equipped for the securement of either conventional wheelchairs with the special seats (b) or the special Hangrail hanger (c). These vehicle seats, for use by ambulatory passengers, can be quickly installed and removed and are secured utilizing the same installations as required for the wheelchair passengers.

   This seat should not be confused with the mobile seat, (b) above.

## 1.2 Current Use of Hangrail System

The FFG Hangrail Lift System is currently being utilized by the Arbeiter-Samariter-Bund (ASB) in Achern, West Germany. The ASB is a social service organization, with branches throughout Germany, that looks after the welfare of members and their dependents; it performs many functions that, in Canada, would be undertaken by Provincial health organizations or the Workers' Compensation Board.

The ASB in Achern is currently the only organization that is in possession of a full sized vehicle equipped with the Hangrail Lift System. They also have a number of smaller vehicles with the modified system. These smaller vehicles are utilized to pick up disabled persons from neighbouring areas and to bring them to the large vehicle. Following egress from the small vehicles and subsequent access to the large bus the passengers are taken to a school for the handicapped some 60 km distant. On the return journey the smaller vehicles are again used for the short distance local trips.

The reason that the system is currently not more widely utilized is that the initial system supplied to the ASB in Achern has been used as a prototype in operational development. With the help of the ASB and the SWEG (Sud-West Deutsche Eisenbahn Gesellschaft), the transit operating authority, a number of recommended modifications and refinements to the system have been identified. The manufacturer, FFG, is making every effort to improve the system as much as possible prior to further production. It is felt that all the modifications have now either been undertaken or the requirement has been identified, and further production of the system, with improvements is thus possible.

## 1.3 Data Collection

The data collection for this project was undertaken by the author in Germany in 1984. Data were subsequently reviewed and evaluated by other members of the project team in Canada. The data collection was principally undertaken in two locations; in Hamburg at the offices of the designer and

manufacturer, FFG Fahrzeugwerkstatten Falkenried GmbH (Falkenried 7-19, D-2000 Hamburg 20, West Germany; telephone 040/4713-1; telex 02 11586 ffg d) and on site with the current user of the system, at Achern, south of Baden-Baden. The system is used by the Arbeiter-Samariter-Bund Landesverband Baden-Wurttemberg e.V., (Geschaftstelle des Ortsverbandes Mittelbaden, Scheffelstrasse 24-26, 7590 Achern; telephone 07841 1888).

One of the chair systems, the Innovint On Board Wheelchair, is manufactured by Innovint-Einrichtungs GmhH, (Hinschenfelder Strasse 22, D-2000 Hamburg 70, West Germany; telephone 040/6959600; telex 2165240).

## 2. THE FFG HANGRAIL LIFT SYSTEM

### 2.1 System Description and Components - Large Bus

The Hangrail Lift System (Gleitlift) is a component modification that has initially been designed for use on European U80 type buses but which can also be adapted to other bus types. The Hangrail Lift System is not restricted to any single bus manufacturer or model since the U80 type is common to many European manufacturers. The system consists of a long, rectangular panel in the side of the roof of the vehicle which can be activated to extend sideways out from the bus. A hollow beam section is suspended, at an inclined angle, from the panel. In the hollow beam runs a continuous chain, driven by a power source on the bus. This chain moves the wheelchairs, fitted with adapters, into the vehicle. The top of the wheelchair adapter must be induced into the hollow beam at the lower end, where it becomes attached to the chain. The system is similar in concept to a ski lift. Near the front door the hollow beam section of the hangrail is joined to a shorter curved beam. This shorter segment is stored within the vehicle. This section is released from its location and swung into the correct position to coincide with the hollow beam section in which the chain runs, thus making a continuous guideway in which the wheelchair adapter can travel. It should be noted that the curved section of the rail does not have the driving chain inside it, and forward movement of the wheelchair in this section is provided manually.

Once inside the vehicle, the wheelchair (and adapter) can be removed from the rail and pushed to the required location within the vehicle to be secured into position.

The Hangrail Lift System operates either with a specially designed chair or with conventional wheelchairs to which an adapter is attached, enabling the chair to be elevated into the vehicle and subsequently secured into position. The hanger, by means of which chair and passenger are moved into the vehicle, is an integral part of the construction of the specially designed chair.

Figures 1, 2 and 3 show three views of the Neoplan bus equipped with the Hangrail Lift System. In Figure 1 the panel that extends with the Hangrail can be seen. It extends from the front door back to the rear door and, when in the secured position, is totally unobtrusive. Figure 2 shows the left side of the bus and in Figure 3, a view from the rear of the vehicle, can be seen some of the special seats secured in position in the vehicle. The area to the left of the vehicle photographed contains the washroom.

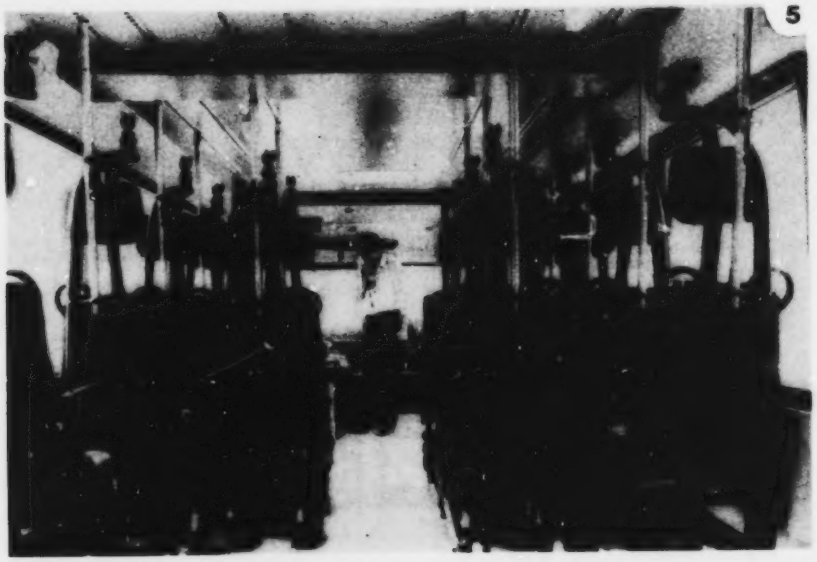
The vehicle interior is capable of accommodating twenty-four of the special mobile seats and seven fixed seats. These fixed seats are located as follows: two immediately behind the driver's position, one behind the other; there are two similar seats on the opposite side. These four seats are located over the wheelwells. At the rear of the vehicle there are two more fixed seats. Two views of the vehicle interior are shown in Figures 4 and 5 and Figure 6 shows the boarding system. The capacity of the vehicle is variable dependent upon the type of seating utilized; use of the special mobile seats increases the vehicle capacity as these seats take up significantly less room than a conventional chair fitted with an adapter. Floor plans of a vehicle are shown on page 10. Using the special seats the vehicle capacity is thirty-one compared to a capacity of sixteen when conventional wheelchairs are used. Designs have been prepared for coaches fitted with Hangrail systems to accommodate in excess of forty passengers.

**Neoplan Bus - Exterior View**
**Figure 1**

**Neoplan Bus - Exterior View**
**Figure 2**

Figure 3
Neoplan Bus -
View From Rear

Figure 4 Interior Of Vehicle

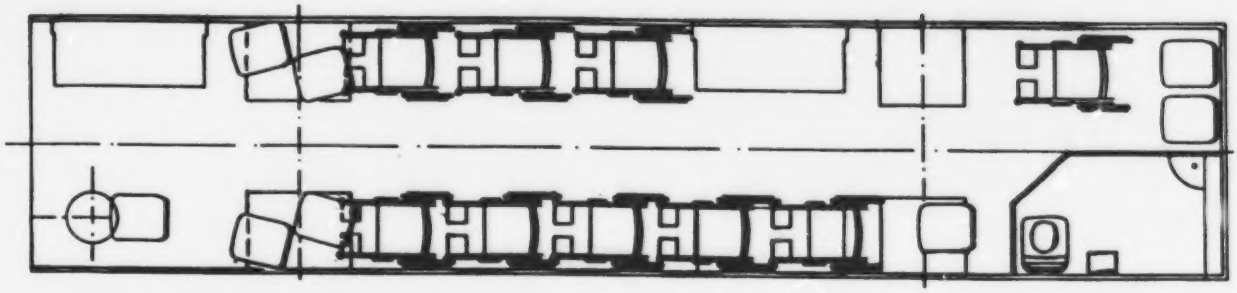



Interior Of Vehicle -
Showing Special Mobile Seats
Figure 5

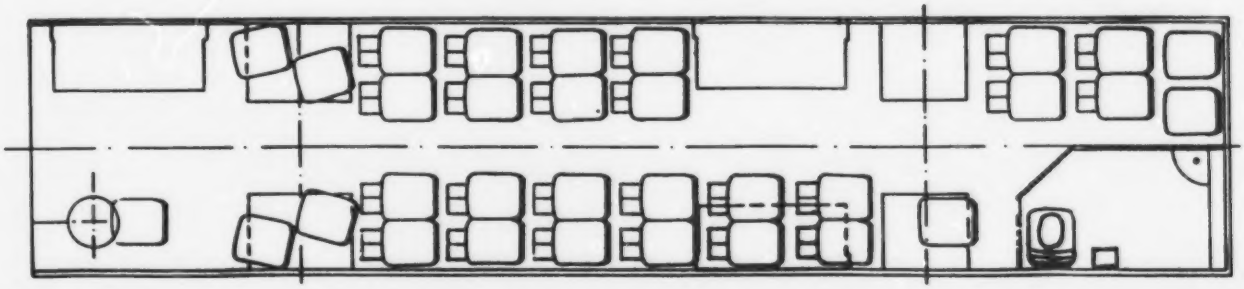
Passenger Boarding Bus By Hangrail
Figure 6

**Vehicle Floor Plan**

a) With Conventional Wheelchairs



b) With Special Mobile Seats



The operational procedure for vehicle access and egress by disabled persons is explained by means of a brief description of the actions, in sequence. A total loading sequence is described, with photographs, in Appendix A.

2.1.1 The Special (Mobile) Seat

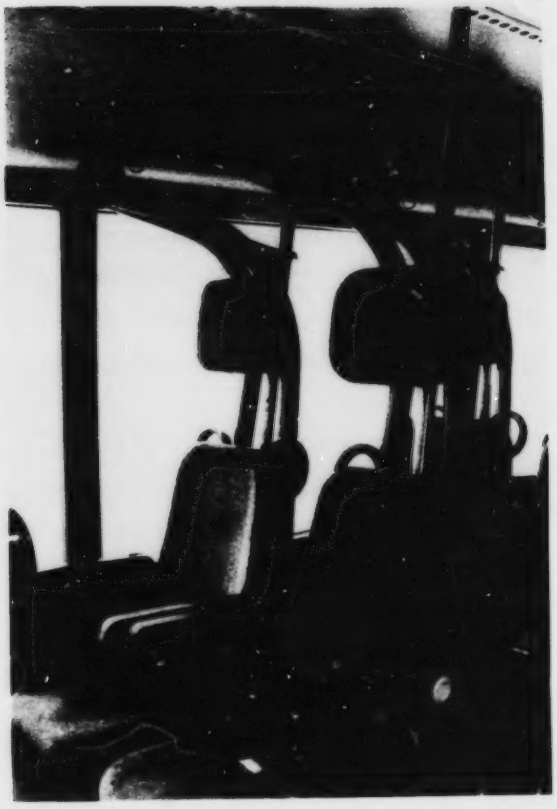
As previously discussed, the Hangrail Lift System is currently used principally in conjunction with the specially designed seats equipped with four wheels, with the hanger component an integral part of the chair's construction. This seat (called Rollsitz in German, as opposed to Rollstuhl, wheelchair) offers

significant advantages over use of a conventional wheelchair. The principal advantage is that the seating capacity of the vehicle is considerably increased by the use of the narrower mobile seats. The special seat can be seen in Figures 6, 7, 8 and 9. In Figure 6 the seat is seen suspended from the Hangrail. Note the hanger, as well as the armrests, footrest and wheels. Figure 7 shows the seat in some detail. Figure 8 shows two seats inside the vehicle. The hanger component is itself no longer utilized, however an extended securing pin that is located between the two vertical sections of the hanger holds the seat into position by locking into special rails in the vehicle roof. Similar rails are located on the floor. This can be seen in Figure 9.

**Figure 7**
**Special Mobile Seat**

The special seat that is currently used is equipped with wheels so that it can be moved into a school, restaurant, hotel or other location after leaving the bus. The rear wheels on the seat can be hinged outward to a location on the outside of the lateral frame member. This increases the stability of the chair when it is in use outside the vehicle. For use of the chair inside the bus the wheels should be in the inward position to facilitate the positioning of chairs beside each other. The passenger in the mobile chair requires assistance to be pushed from one location to another. This is a current disadvantage of this system, however a different chair design is being considered.

8



Mobile Seats
Figure 8

9

Mobile Seat
Figure 9

Passengers utilizing the mobile chair are expected to generally use it for the duration of the complete trip; that is, to be in it at commencement of the trip, remain in it during the journey and, following egress from the vehicle, to remain in it until the return trip.

While there may be some disadvantage in the inability of the passenger to move between locations by himself or herself this must be compared to the advantage of increasing the vehicle capacity by use of the mobile chairs, and greatly decreasing the loading/unloading cycle time. It is likely that the use of the mobile seats opens up many opportunities previously not available due to space and time constraint of using conventional wheelchairs.

The mobile chair has been designed with considerable ergonomic input and is comfortable for a range of physical sizes. Future versions of the seat might be constructed such that the seat can be rapidly raised or lowered to accommodate passengers with different physical proportions.

The mobile seat is equipped with a footrest, armrests and a lap belt. There is a headrest and two handles are conveniently positioned for pushing the passenger and chair.

### 2.1.2 The Converter Hanger

Conventional wheelchairs cannot gain access to a Hangrail equipped bus without the use of a converter hanger. This device is a means whereby a conventional wheelchair can be transformed into a chair that can be linked to the Hangrail chain and thus be drawn upward for access to the bus or, conversely, drawn downwards for egress. The use of the converter hanger is definitely a less favourable option than the use of the special mobile seats. It takes some time to secure the hanger to the conventional wheelchair and, because of the great number of wheelchair manufacturers and their lack of design consistency, the hanger cannot be made readily adaptable to all wheelchairs. Even when the hanger is successfully utilized the principal drawback of the conventional chair taking up so much space is not avoided.

A chair fitted with the converter hanger can be seen in Figure 10. In this photograph the chair is being pushed along the curved section of the rail, into the vehicle.

**Conventional Wheelchair Fitted With Converter Hanger**
**Figure 10**

The converter hanger, despite being utilized with conventional chairs that take up considerable space in the vehicle, can perform a very useful function. If rapid attachment and detachment is achievable the hanger can be removed from the chair thereby permitting the disabled person to move around by utilizing the chair. The hanger could then be reattached for entering into the vehicle again, for a return journey home for example.

### 2.1.3 The Emergency Egress System

Concern is frequently voiced respecting the means of exit by disabled persons from a vehicle in the case of an emergency. In most instances vehicles that are equipped with wheelchair lifts must rely on those same lifts for all access and egress requirements. As has been previously discussed, conventional type lifts are generally too slow for normal boarding and exiting requirements when large numbers of passengers are involved. Those lifts are totally unsuited to effect an emergency exit from the vehicle.

The designer of the Hangrail Lift System has noted the necessity for an improved exit system for disabled persons, and has designed and equipped the large bus with such a device.

The basic concept of the emergency egress system is similar to that of the Hangrail System - a specially equipped chair can be suspended from a rail and lowered to the ground. The emergency system consists of a single rail section that is secured inside the vehicle, at the rear of the vehicle on the left side. The rear door of the vehicle is used for exiting. The operation of the emergency egress system is described in Appendix B.

## 2.2 Perceptions and Feelings of the User

During the evaluation process the author rode up and down the Hangrail Lift System many times and interviewed others who used the system. Some had used the system on many previous occasions while others had only recently become acquainted with the system.

To gain access to the vehicle the operator pushes the wheelchair passenger forward until the hanger is inserted into the opening at the lower end of the rail. When the chain catches with the connector on the hanger the chair and passenger are drawn forward. The commencement of this motion is barely perceptible - there is almost no jerk associated with the forward movement. There is no sensation of undue upward motion as the chair and passenger ascend the Hangrail. The angle of ascent/descent is approximately $9^{o}$ - this can be seen in Appendix A, Figure A24. Similarly there is no feeling of undue speed on ascent or descent. Under normal conditions it takes approximately twelve to fifteen seconds to ascend the full length of the chain, a distance of approximately 4.8 m. This equates to a speed of about 1.15 km/hr or 19.2 m/min. There is a gradual decrease in forward motion as the hanger is released from the chain and passes from the main rail section into the curved rail, in which, for further forward progress manual force is required. When the wheels of the chair make contact with the floor of the bus the operator or assistant continues to push the chair until the hanger is pushed out of the end of the rail. There is no sensation of jerk when this occurs.

An obvious concern, upon observing the Hangrail Lift System, is the extent of the sensation of swinging or hanging from the overhead rail. From the author's personal experience, and from the interviews, it can be categorically stated that there is absolutely no feeling of insecurity. There is minimal forward/backward movement of the chair and no lateral movement. There is an absolute feeling of safety - more so than experienced by most persons on a wheelchair lift. First time passengers on the Hangrail Lift System commonly exhibit a certain amount of nervousness with respect to the system, however after the first round trip they are almost always fully at ease. It is worth remembering that the system, as currently utilized, is used by the same

persons twice daily. These passengers are supremely at ease with the entire system. There is no reason to believe that any passenger would exhibit signs of anxiety past the first very few encounters with the system.

The feelings of movement are similar for the exiting procedure as for access - there is no undue sensation of speed, forward jerk, insecurity in being suspended from above or lateral swinging motion.

### 2.3 Hangrail System Costs

As previously mentioned the Hangrail system can be incorporated into a number of bus designs including the new generation of Steyr vehicles and S80 and U80 (Uberlandlinienbus) models. Ideally the required changes for installation of the Hangrail system should be made at time of construction of the vehicle. If this is not possible the retrofit can be accomplished, however additional strengthening of some parts is required. Due to a variation in possible requirements it is difficult to accurately cost a complete system, however the following figures provide an indication of the appropriate costs. Costs are expressed in DM in 1984 costs, with equivalent Canadian Dollar costs based on DM 1.00 to $0.42 Canadian.

| | | |
|---|---|---|
| . approximately cost of suitably adapted bus | DM 230,000.00 , | $96,600 |
| . installation of Hangrail and components including perforated strips in floor and ceiling | DM 50,500.00 , | $21,200 |
| . special mobile seats (approximately 24 required, depending upon vehicle layout) price per seat | DM 2,500.00 , | $ 1,050 |
| . fixed seats inside vehicle (approximately seven required) price per seat | DM 600.00 , | $ 250 |
| . emergency exit system with brake assembly | DM 14,000.00 , | $ 5,900 |
| The handicapped washroom can be added to the vehicle for an approximate cost of | DM 22,000.00 , | $ 9,200 |

The time requirement for provision of a complete vehicle from receipt of order is likely in the area of six months.

The operating cost of the Hangrail system is difficult to determine as the current user has not been able to specifically separate the Hangrail costs from other vehicle operating costs. The operator has noted that the cost is insignificant and that the time savings made possible by the system are the most important aspect to be considered.

## 2.4 System Description and Components - Small Bus

Access to the large bus described in previous sections of this report can either be attained by transportation of the passengers singly to a central point or by using small specially equipped vehicles as feeders to the large bus.

The Arbeiter-Samariter-Bund has equipped a number of Mercedes Benz 207D vans with special access means compatible with the Hangrail System of the large bus.

The system for loading and unloading wheelchair passengers (either in the special mobile seats or in conventional wheelchairs with the converter hanger) resembles an elephant's trunk extended from the rear of the vehicle. The rail, which is normally folded inside the vehicle can be positioned such that the rail extends from the vehicle so that the attachment on the chair can be pushed into it. The rail is then raised by means of an electric motor and the passenger can be pushed into the vehicle.

Figure 11 shows one of the small vehicles used by the ASB in Achern. Figure 12 shows the rail in the stored position.

The operational procedure for the small bus system is described in Appendix C.

**Figure 11**
**Small Collector Vehicles,**
**Mercedes Benz 207D**

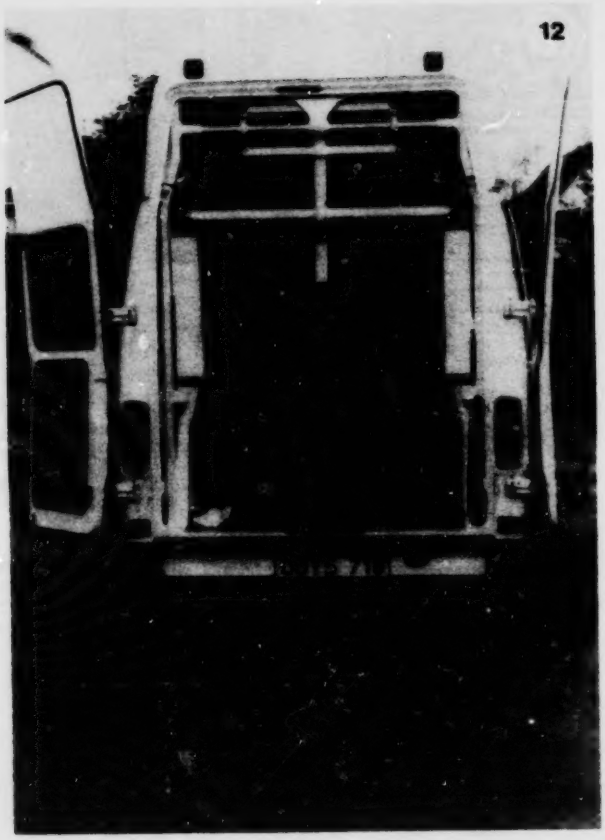
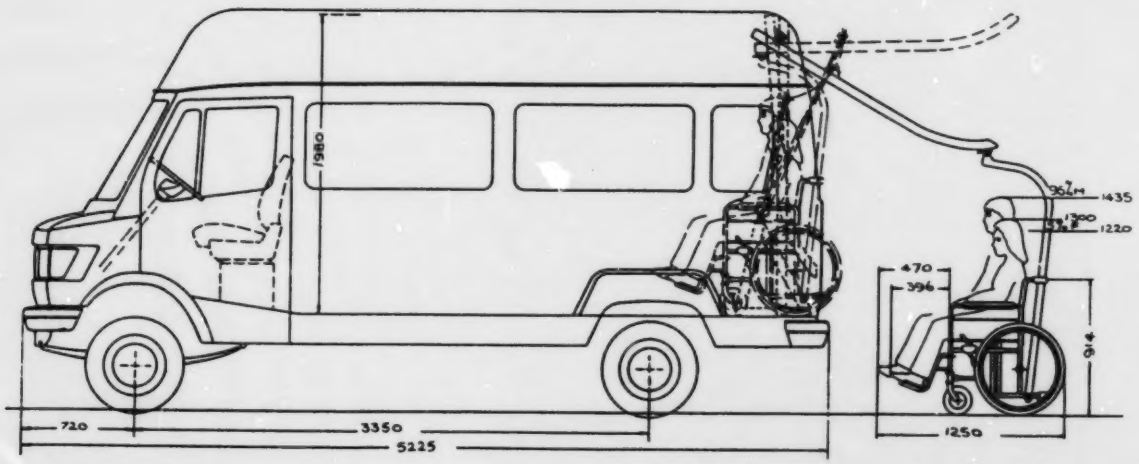



**Figure 12**
**Rear of Vehicle Showing**
**Rail in Stored Position**

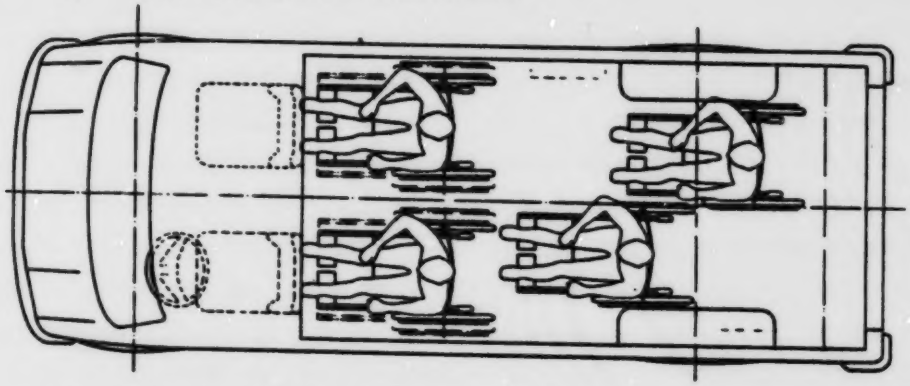
The operation of this means of loading and unloading wheelchairs into and out of the small vehicle is reasonably speedy. However, unlike the Hangrail system, a sequence of events must be undertaken for each passenger. Each passenger does not require a complete sequence, which includes the extending of the rail from the stored position to the operational height, but does require induction into the rail, to be raised and pushed out into the vehicle, following which the rail is lowered to accept the next passenger. The raising of the device from the stored position to its full height takes approximately twenty seconds. From the induction of the hanger into the rail until the passenger can be pushed out into the vehicle takes about ten to twelve seconds. A similar time is required for lowering the passenger to the ground. The following diagram shows the side view of the vehicle and the lift system.



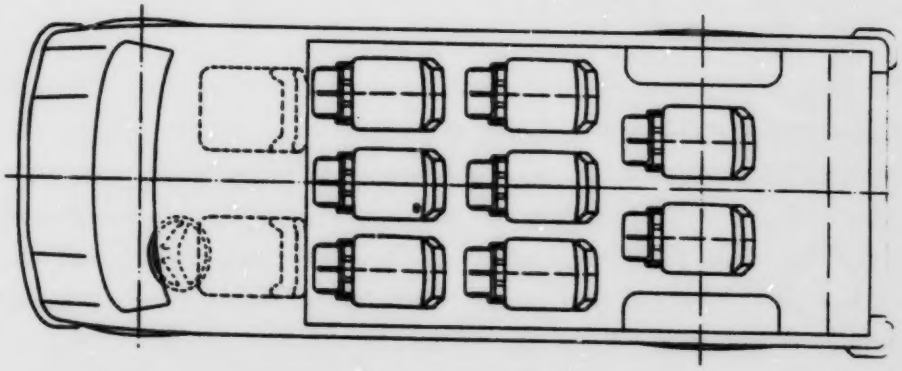
Use of the special mobile seats with this vehicle increases the capacity, as was similarly indicated with the large bus. The two following diagrams show the vehicle floor plan with conventional wheelchair and with special mobile seats. Note that a maximum of four passengers can be carried using conventional wheelchairs, whereas up to eight passengers can be accommodated in the vehicle if using special mobile seats.

**Vehicle Floor Plan**

a) With Conventional Wheelchairs



b) With Special Mobile Seats



As has been discussed, the small vehicle, just like the large bus, can accommodate passengers either in the special mobile seats or in conventional wheelchairs with the converter hangers attached. There are alternative seating types available for ambulatory persons. Seating option for the small bus are described in Appendix D.

## 3. FINDINGS

The Hangrail Lift System is not a single technical innovation but a concept with many components necessary for successful implementation.

The main component of the system is the Hangrail, which is a modification to a transit bus. This device addresses the two major problems of loading/unloading cycle time, and space utilization. Conventional mechanical lift devices must make numerous complete cycles of operation, once for each passenger, and are thus time consuming. Utilization of a system on a continuous loop, like a ski lift, permits for the rapid access and egress of passengers. For disabled persons the delays incurred in loading or unloading a vehicle are commonly a limiting factor in the use of a large vehicle.

The second major problem experienced in using conventional wheelchairs and loading devices is the large space requirement for each wheelchair passenger. If only relatively few passengers can be carried in a large vehicle the per unit distance cost per passenger is high, which also can be a limiting factor on the use of a large vehicle for long distance trips. Any increase in vehicle occupancy will bring down per passenger cost and may enable the trip to be economically feasible.

The hangrail lift system addresses both the above problem areas, first by providing a boarding/deboarding device that is rapid and secure, and secondly by utilizing (preferably) a special chair unit that is compatible with the access/egress device and takes up less space in the vehicle than a conventional wheelchair. The securement devices for the special chair are rapidly deployed and are secure. There is no requirement to bend and fasten belts or hooks, and there are no parts to be left attached to vehicle sidewall or floor.

The Hangrail system is also utilized in providing a rapid emergency exit system from the vehicle. In this case a separate single rail unit is utilized and this can be extended from any door in the vehicle that is appropriately equipped.

The Hangrail system is again used in a modified fashion in the smaller collector-type vehicles. In these vehicles there is no chain running inside the rail but the rail itself is lifted once the chair hanger has been inserted, and the passenger can then be pushed into the vehicle. Again the use of the specialized seats increases vehicle capacity. The in-floor securement strips utilized for securing either the special chairs or conventional chairs with the adapter hangers can be used for securement of quick release seating, either single seats or bench seats. The seats can be customized to meet the requirements of particular individuals by replacement of the seat unit by a special seat, appropriately contoured.

The Hangrail system is an ingenious means whereby the use of large capacity vehicles is facilitated by technological innovations providing for rapid boarding and deboarding, and increased vehicle capacity.

While the system is currently in use in Germany it is a new innovation and has not yet been widely marketed. The unit currently used by the ASB has performed extremely well but, as one would expect from an operating prototype, certain possible improvements have been noted. Modifications will be made to subsequent units. Specific aspects of the current design that may be changed in the future include the adapter hanger unit, the special mobile seat and the emergency exit.

The adapter hanger must be designed so that it is attachable to a very high proportion of wheelchairs, and it must be capable of handling the strains incurred with the heaviest wheelchairs and heavy passengers. For long trips, for which the vehicle is principally designed, passengers should probably not be permitted to travel in electric wheelchairs but should be in manual chairs or special seats. The electric wheelchair may possibly be carried in the luggage compartment for use at the destination. This would permit the hanger unit to be redesigned to be lighter in weight and its securement system to the wheelchair could be simplified.

A major modification that is being considered is the replacement of the current special mobile seat by a new design. The new seat is manufactured by Innovint and was originally designed for use in aircraft and other transportation modes. The chair is less cumbersome than the current chair, manufactured by Vogel, however the most important innovation is that a large wheel can be added to the chair and it can thus be converted into a manually operated wheelchair for use outside the vehicle. The Innovint On Board Wheelchair can thus be used both as a passenger seat inside the vehicle, with large wheel detached, and as a wheelchair for moving around outside the vehicle, with wheel added. Figures 13, 14 and 15 show the Innovint chair, without large wheel, with large wheel attached and folded, respectively.

Another change that is envisaged is a modification to the system whereby the hanger moves inside the Hangrail. Currently, as can be seen in Figures A19, A22, C11 and C13, the top of the hanger is equipped with a roller platform to which four rollers are attached, that run in the Hangrail. In order to facilitate both a weight reduction and a cost saving for each hanger it is hoped to equip the rail itself with a roller system such that the hanger does not require rollers. Inside the rail could be a succession of rollers and the hanger would have an attachment that would run inside the roller equipped rail.

Another area of possible improvement is the emergency exit system. It is likely, in the opinion of the author, that this system would seldom be required because it is unlikely that the main Hangrail located in the vehicle roof would be damaged in a vehicle collision. The emergency exit, if installed, may not be required on both sides (as is the case with the vehicle used by the ASB) but simply on one side. The designated door should be to the rear of the vehicle in the event that any damage incurred in a collision does not permit the opening of the front vehicle doors. The design of the emergency deboarding rail could possibly be improved to facilitate handling and permit more rapid deployment.

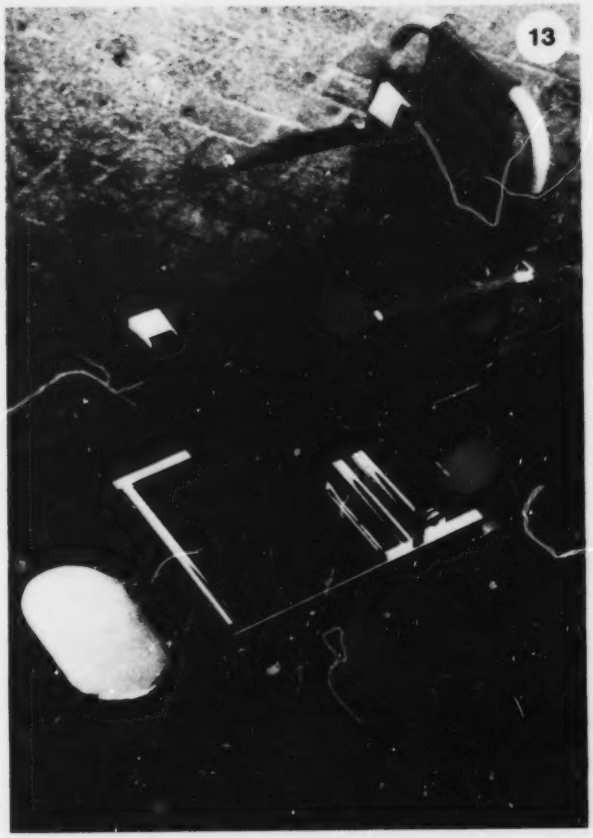



Figure 13
Innovint On Board Wheelchair -
Without Large Wheel

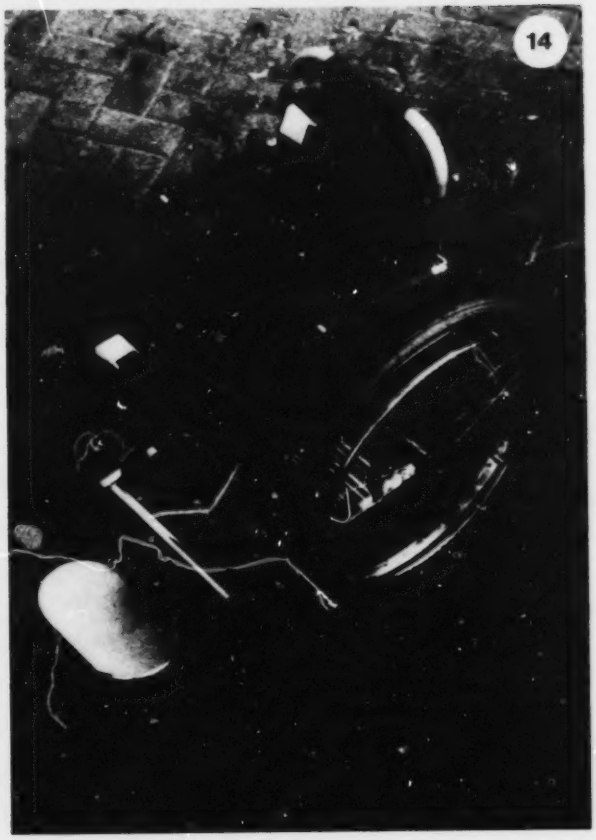



Figure 14
Innovint On Board Wheelchair -
With Large Wheel Attached

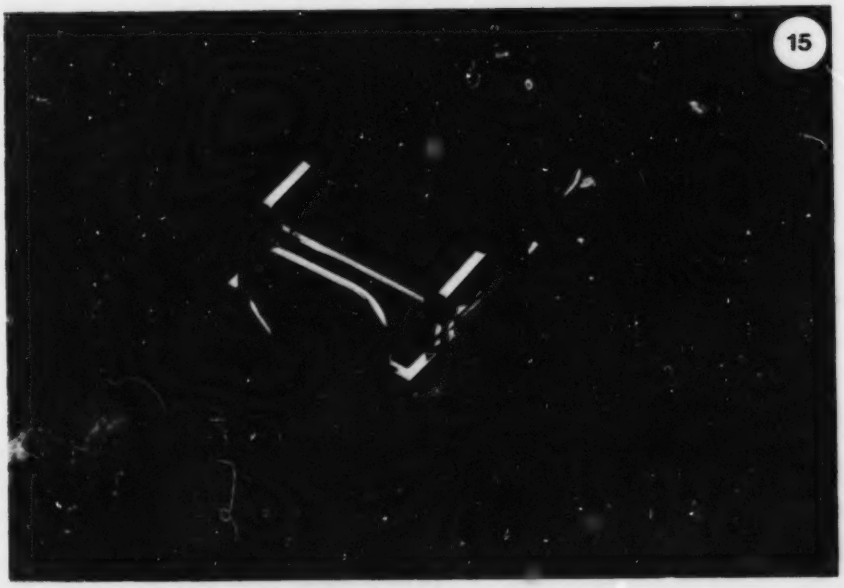



Figure 15
Innovint On Board Wheelchair - Folded

Undoubtedly there are many small refinements that can be made to the system components to improve its aesthetics or performance. The adapter hanger unit has, for example, already been modified from the design in Figure 10 to the more streamlined design as shown in many of the other photographs.

Although there is currently no perception on the part of users of being handled somewhat like cargo, by being suspended from the Hangrail, every effort must be made to avoid this comparison. Due to the unconventional approach to vehicle access and egress by the Hangrail system it is automatically subject to criticism and one such criticism from those who are unfamiliar with the device is its comparison with cargo handling devices. It should be pointed out that while this observation has some validity there are specific advantages to being suspended from the Hangrail rather than sitting upon a platform that is raised and lowered. The safety of the former system exceeds that of the latter and all passengers interviewed felt comfortable with the system. Although the designs of both the Hangrail system and the small bus access/egress system are technically advanced there are some aspects that are not fully satisfactory from an ergonomic viewpoint. Some of these shortfalls can likely be resolved in future design modification; others can probably not be fully addressed while retaining the benefits of the Hangrail system, of rapid vehicle access and egress, and increased vehicle capacity.

The ergonomic evaluation, undertaken by U. Rutenberg, of Rutenberg Design Inc., is presented in Appendix E.

## 4. CONCLUSIONS AND RECOMMENDATIONS

The concept of the Hangrail system is a tremendous breakthrough in transportation for the handicapped. The system, as utilized in the large vehicle, opens up opportunities for transportation for disabled persons which were previously not possible. Due to the requirement for utilization of specific hardware the same basic system has been incorporated into the

smaller collector vehicles. In instances where these smaller vehicles operate in association with the large type vehicle this is efficient; however, the use of the "elephant trunk" system in the small vehicles in isolation is not a viable proposition.

Despite the significant advances made by development of the Hangrail system and the overcoming of the two major problems of speed of access/egress and vehicle capacity, the system is not entirely without its own drawbacks. Unfortunately, in order to overcome the aforementioned problem, use of special equipment is necessary. It is the need for the special equipment - either the special mobile seat or the adapter hanger, that adds a constraint to the adoption of the Hangrail technology. There is a requirement for the passenger to ideally be seated in a special mobile seat prior to accessing the vehicle. Having exited from the vehicle, at the completion of the journey, the passenger is restricted in the use of the special seat as this seat requires pushing; that is, it does not have its own large wheels by which the operator can control his or her own movement. This factor is the principal drawback in adoption of the current system. Use of the new Innovint chair would be a great advantage.

The system's applicability is limited to situations where a large number of handicapped persons need to be transported on a regular basis to a reasonably distant location at which they do not require extensive mobility. Under the above circumstances the Hangrail system is ideal. The passengers can be rapidly loaded into the vehicle, quickly and safely secured and can deboard the vehicle in a short time. The passengers, if not requiring to be very mobile at the destination, can remain in the special mobile seats for the duration of their stay and can then commence the return journey.

Unfortunately, while very successfully addressing the vehicle access/egress and on board securement problems, the Hangrail system does not solve the problem of many disabled persons who simply wish to travel to a distant location and upon arrival have the same freedom of mobility that they had at the origin. This ideal is not incompatible with the required increase in speed in boarding and deboarding and the increased vehicle capacity. A very

exciting development is the introduction of the Innovint On Board Wheelchair to which the adapter hanger can be attached. In this manner the Hangrail system can be utilized. At the destination end the large wheels can be attached to the On Board Wheelchair and the passenger can operate it in the same manner as a conventional manual wheelchair.

It is suggested that there are undoubtedly situations in Canada (and in the United States) where the requirements are such that the Hangrail Lift System would be ideal. An example of a potential situation that comes to mind is where a number of children or adolescents need to travel on a daily basis to a centre for training or rehabilitation. Such centres cannot be located in all urban areas hence there may be a need to transport persons quite some distance to such a centre.

Where only conventional lift systems and limited vehicle capacities are available it may not be economically feasible to provide such a transportation service. With the use of the Hangrail Lift System, however, the training or other social services may be attainable.

It is unfortunate that the Hangrail Lift System is not a magic panacea for all the transportation problems encountered by the disabled. The fact that it is not should not, however, detract from the very significant advantages that this novel technology can provide under the correct set of circumstances. This technology should be publicized and where it is evident that its use would be beneficial a pilot project should be established.

The Hangrail Lift System is a great advance in vehicle boarding and deboarding systems. Unlike so many other attempts to introduce new technology, the development has been undertaken in a highly professional and most impressive manner. The system that is currently operating in West Germany has been extremely extensively tested and monitored and some further modifications and refinements are planned by the developer. With these in place the system will be of even greater value in those instances where its use is appropriate.

The Hangrail Lift System has great potential under certain conditions. The introduction of this technology under those conditions could increase transportation services available to the disabled, due to increased cost effectiveness. Transport Canada should undertake a well prepared publicity program to advise potential operators of the availability of this system. Instances where the system may be appropriately utilized should be analyzed and, following selection of a suitable operating site it is suggested that a pilot project be established.

Canada has for years acknowledged the importance of reducing mobility barriers to the disabled. Promotion of this advanced technology and support for its introduction in an appropriate location should not be neglected.

# APPENDIX A
# HANGRAIL SYSTEM LOADING AND UNLOADING SEQUENCE

## APPENDIX A

## HANGRAIL SYSTEM LOADING AND UNLOADING SEQUENCE

There are two principal control stations for operation of the Hangrail System. One control station is adjacent to the rear door of the bus and the other immediately behind the front door. The two control stations are so located such that the operator is in the optimum location for performing the functions controlled by each station.

Vehicle Arrival:

- the vehicle is driven to the desired location and the handbrake is applied;
- driver presses button on driver control panel to open front door;
- driver leaves seat and exits vehicle by the front door.

Preparation of Hangrail, Main Section:

- driver walks to rear door of vehicle;
- opens door on control panel located in front of rear door (location can be seen in Figure 1);
- the control panel can be seen in Figure A1. There are two buttons at the top portion of the panel, below which is located a toggle switch. This switch determines to which system the power is directed - either to the two top buttons (which control the inward/outward movement of the lift system from the vehicle and the upward/downward movement of the rail), or to the button at the bottom of the panel which controls movement of the chain mechanism inside the rail. The top button (Heben + Einschienben) controls the raising of the rail and its inward movement into the top of the vehicle. The button beneath this one (Ausschieben + Senken) controls the outward movement of the system and, when it is extended, the lowering of the rail component.
- the driver presses 1 on the toggle switch and then presses the second button from the top (Ausschieben + Senken) to activate the outward movement of the panel and rail. When the panel is fully extended outward, the rear end of the rail descends;
- driver releases button when he thinks that the height of the rail is correct;
- driver pulls down measuring rod that is affixed to the lift and moves rail to correct height by means of pressing either the top (upwards - Heben) or second (downward - Senken) button. See Figure A2. The hangrail is now in the extended position, correctly aligned (see Figure A3). (Note the instructions on the door panel - see Figure A1

and Figure A4. These instructions are complete in that they give total directions from putting on the brake, starting the engine, ensuring that all three emergency buttons are not depressed, ensuring that master control switch on driver panel is in correct position, etc.).

Preparation of Hangrail, Curved Section:

- driver re-enters the bus to manually secure the second section of the hangrail to the main section;
- driver releases the catch that secures the rail section to the vehicle wall above and behind the driver's position;
- driver manoeuvres the rail section into position. Note that this section is suspended from two hangers that move into special channels in the vehicle roof - these can be clearly seen in Figure A5;
- Figure A6 shows the rail section being moved into position. The end of the rail in the right of Figure A6 is swung out of the door and is secured by means of a spring catch to the main rail section - see Figure A7. The rail section can be seen in Figure A8, almost together, and coupled in Figure A9;
- the lift is now ready for use.

Use of Lift for Loading and Unloading Vehicle:

Efficient operation of the system requires two persons, generally the vehicle operator and an assistant. The assistant manoeuvres the passengers inside the vehicle and to and from the Hangrail system which is operated by the driver.

It is assumed that the passengers to be moved into the vehicle are already sitting in the special chairs with the hanger units attached. These chairs may be owned by the passenger or possibly on loan: in any case the passenger utilizes the special chair for the whole day.

- the driver must select the direction of travel of the chain system within the rail - this is done by pressing the toggle switch at the driver's control panel in the desired direction, see Figure A10;
- the Upward (aufwarts) movement of the chain occurs when the button is in position 1, while for Downward (abwarts) movement control switch must be in position 2;
- the upward movement of the chain is controlled from the rear control panel - see Figure A1;

- the downward movement, for exiting the bus, is controlled from the forward control panel. This is located immediately behind the front door. This control panel is shown in Figure A11. The instructions are shown in Figure A12. Note that these instructions are a continuation of those located on the rear control panel. The four points covered in these instructions are briefly as follows:

  (11) put switch on instrument control panel to position 2;

  (12) put switch on rear control panel to position 2;

  (13) press 'Downward' button to start chain;

  (14) feed the special chairs with hanger attachments into the device and exit from vehicle.

The operational control of the system may appear complex from the foregoing description, however, in practice, the operation is not complex. The control stations are located at the position most suitable for the functions they control. Before each major activity (either loading or unloading) the master switch on the instrument panel must be correctly positioned. Apart from this requirement there is no necessity for the operator to move between control stations. The system is impressive both from the aspect of human interface (the location, positioning and design of the control stations) and from the safety features built into the system.

To Load Vehicle:

The process of enabling passengers to enter the vehicle is as follows:

- driver puts control switch on instrument panel to position 1 and ensures that control switch at rear control station is in position 2;

- driver presses 'aufwarts' button at rear control station. This starts the chain drive running;

- driver (or assistant) now pushes special chair towards Hangrail and pushes hanger coupling into opening at end of rail - see Figure A13;

- Figure A14 shows the hanger coupling being pushed into the opening at the lower end of the Hangrail;

- the chain connects with the coupling and the passenger is moved upward by means of the chain mechanism, coupled with the wheelchair hanger, pulling the passenger and chair upwards;

- Figure A15 shows passenger moving upward by means of the Hangrail Lift. In this photograph the driver is walking behind the passenger with hands on the chair;

- at the top of the main rail section the passenger must be manually pushed along the horizontal curved rail. This can be seen in Figure A16 and Figure A17;

- Figure A18 shows a passenger being pushed in through the door. The height of the rail is such that the wheels of the special chair connect with the floor of the bus as the passenger passes the threshhold of the top step;

- Figure A19 shows the passenger being pushed into the bus and the hanger disengaging from the rail;

- the passenger is now wheeled into position in the vehicle - see Figure A20 and Figure A21;

- the chair is now positioned in the selected location - Figure A22;

- the chair is secured into position by two systems, bottom and top. The lower securement system is deployed by pressing downward on a bar that runs between the two upright sections of the hanger. The two securing pins are pushed out from the bottom of the uprights, are located over holes in the railing on the floor and, with downward pressure on the lever, are locked into place. The top system is operated by means of a spring loaded catch. The vertical securing pillar (the top of which can be seen in Figure A14) is pushed upward, the pin positioned into a securing hole in the rail on the roof of the bus and the pillar is locked into position by means of the spring lever being positioned in the top notch on the hanger. See Figure A23.

To Unload Vehicle:

In order to unload the passengers from the vehicle the driver performs the following actions:

- the driver must prepare the Hangrail Lift System for operation as previously described, that is extend the system from the vehicle roof, lower the rail and position correctly;

- prior to unloading, the control button on the instrument panel must be in the 'abwarts' (downward) position 2 and the switch at the rear control station in position 2;

- driver presses 'abwarts' button at forward control station. This starts the chain system running in the downward direction;

- inside the vehicle the assistant or driver releases the two securement systems locking the passenger and chair into position - upward pressure on the off-centre lever releases the lower securing pins and lateral force against the locking handle of the top securing system releases it from the locked position. The vertical securing stanchion can then be lowered to the normal position between the two frame members of the hanger unit;

- the passenger is wheeled along the bus aisle towards the curved rail section;

- the hanger unit is pushed into the opening at the interior end of the curved rail section;
- the passenger is pushed forward, out the door until the hanger unit connects with the chain;
- the chair is moved downward by the chain system until it reaches ground level;
- driver or assistant pushes passenger to desired location.

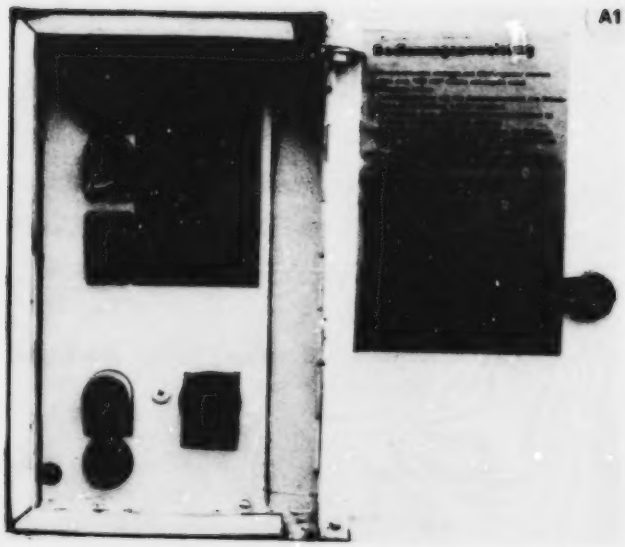
Note that the passenger is facing forward in both the loading and unloading processes.

The unloading process is repeated for all passengers exiting the vehicle. Note that more than one person can be suspended from the Hangrail at any time, both in the loading and unloading cycle. As it is not necessary to maintain manual contact with the passengers as they ascend or descend the Hangrail the capacity of the system is limited only by the ability of the operator to induce hangers into the Hangrail and for an assistant to move the passengers away from the end of the rail, be it either inside the bus or on the ground. Figures A24 and A25 show two passengers being loaded into the vehicle simultaneously.

Up And Withdraw

Extend And Down

Toggle Switch - 1 For Movement Of Rail; 2 For Movement Of Chain Inside Rail.



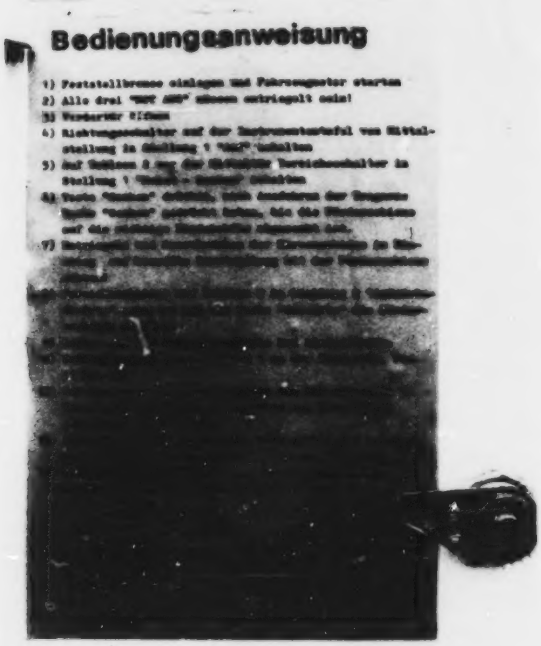

**Control Panel By Rear Door**
**Figure A1**

Figure A2
Operator Adjusting
Height Of Hangrail

Figure A3
Hangrail In
Extended Position

Figure A4
Operating Instructions
On Door Of Rear Control
Panel

A4




A5

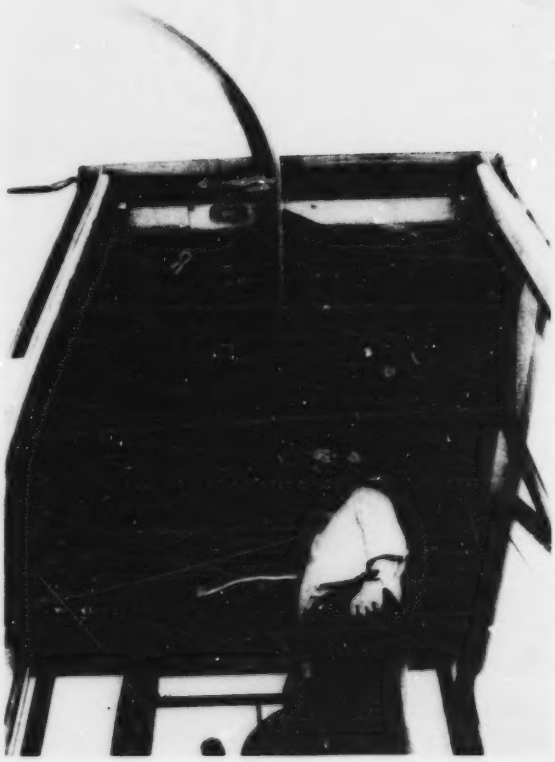


Figure A5
Interior Rail Section
In Operating Position
- Note Channels In
Vehicle Roof

Figure A6
Operator Positioning
Interior Rail Section
For Use

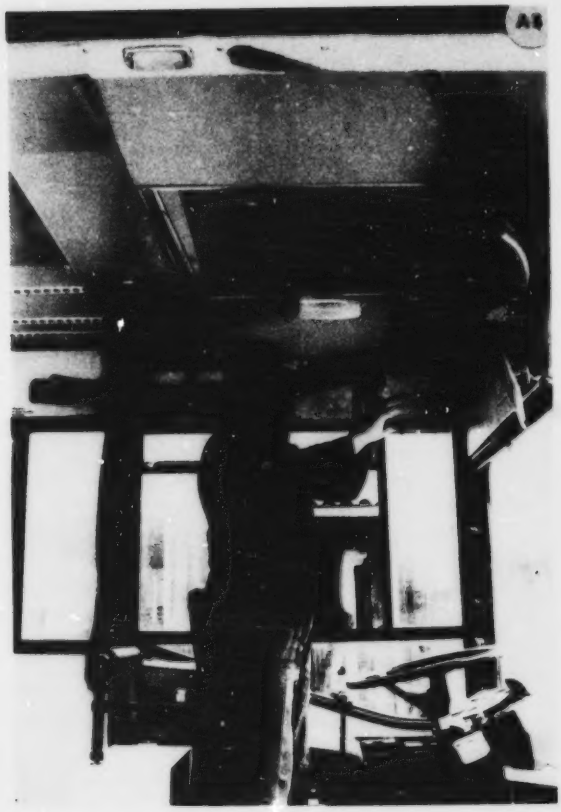
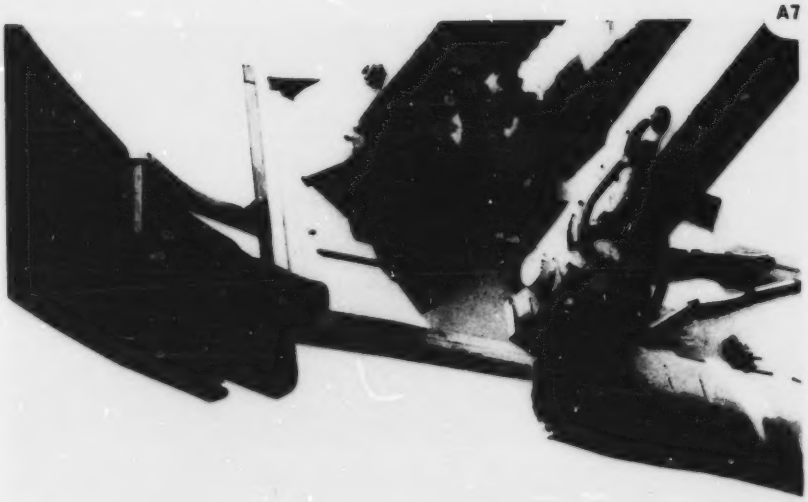
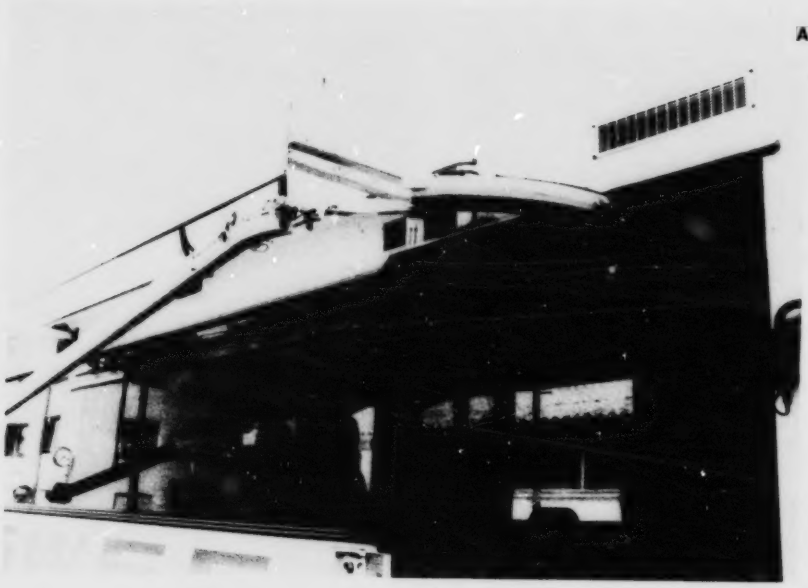



Figure A7
Latch Mechanism
For Securing
Interior Rail
To Hangrail



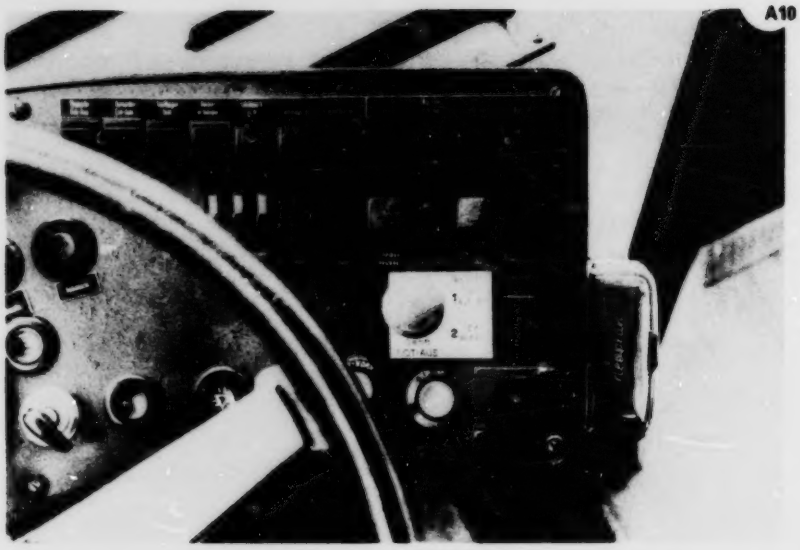
A8



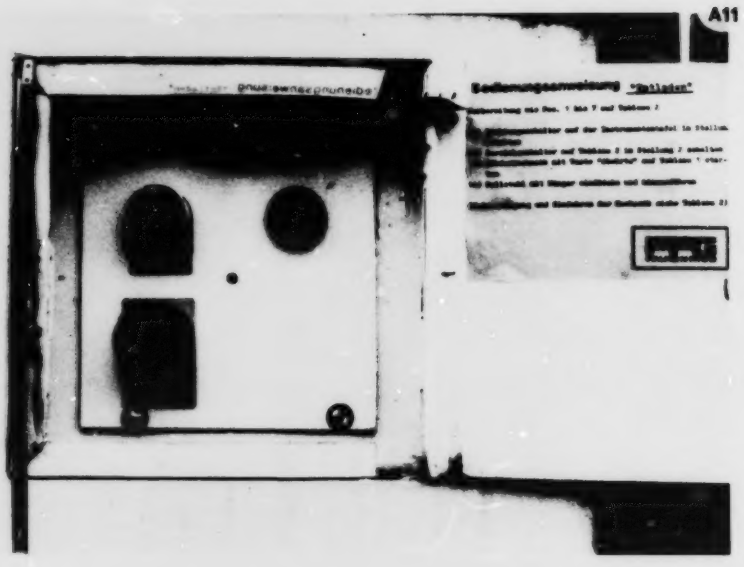
Hangrail And Interior Rail Nearly Coupled
Figure A8

A9

Hangrail And Interior Rail Secured Together
Figure A9




**Driver's Control Panel**
**Figure A10**




**Forward Control Panel**
**Figure A11**

**Figure A12**
**Operating Instructions On Door Of Forward Control Panel**

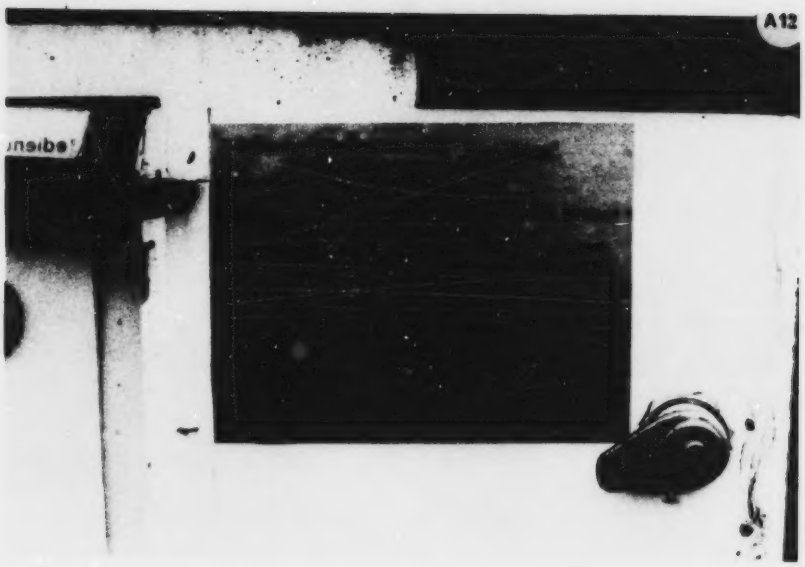



**Figure A13**
**Operator Pushes Hanger Into Opening At End Of Rail And Pushes Chain Operation Button**

Figure A14
Hanger Coupling Being
Inserted Into Bottom
Of Hangrail

Figure A15
Passenger Ascending
Hangrail

Figure A16
Passenger Being Guided
Along Interior Rail
Section

Figure A17
Passenger Being
Manoeuvred Through
Vehicle Door

Figure A18
Passenger Entering
Vehicle

Figure A19
Passenger Being
Manoeuvred In Vehicle
- Note Hanger About
To Leave Interior Rail
Section

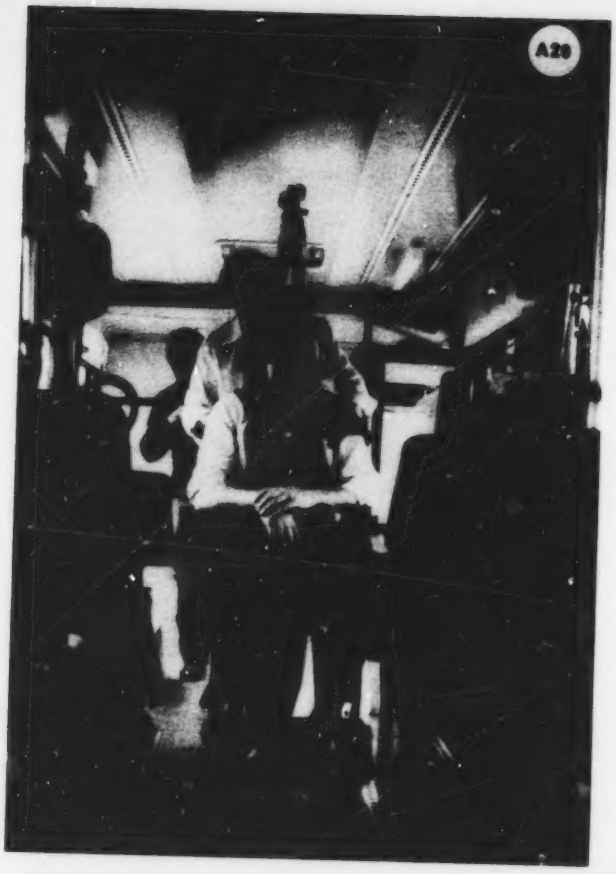
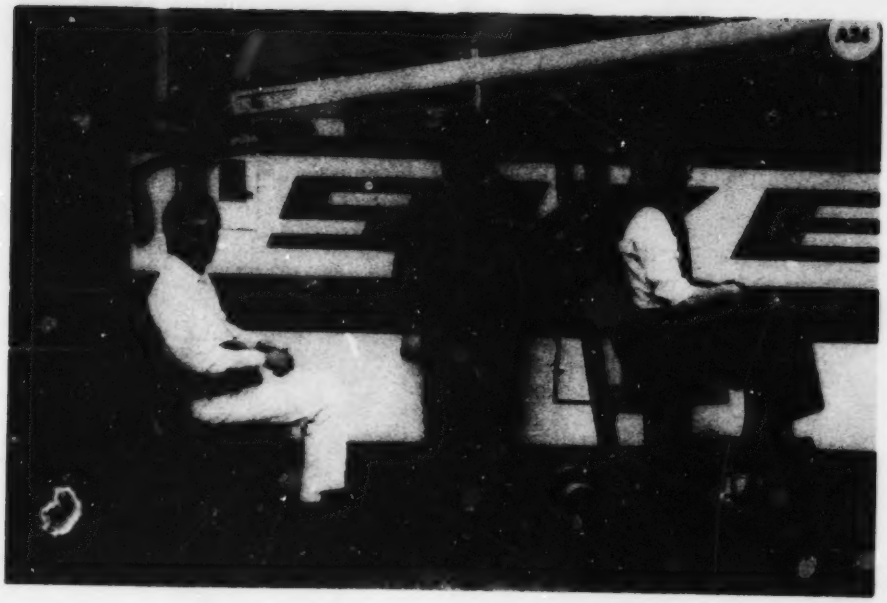



Figure A20
Passenger Being
Wheeled Into Position
Inside Vehicle

Figure A21
Passenger Being
Wheeled Into Position
Inside Vehicle

Figure A22
Special Mobile Chair
Being Positioned

Figure A23
Upper Securement
System Being Locked
Into Place




Two Passengers On the Hangrail
At The Same Time
Figure A24

Two Passengers On Hangrail
Figure A25

# APPENDIX B
# OPERATION OF EMERGENCY EGRESS SYSTEM

## APPENDIX B
## OPERATION OF EMERGENCY EGRESS SYSTEM

The emergency egress system utilizes a rail that is extended outward from the vehicle through a special opening. Above the rear door opening, in the centre, is a small rectangular hatch. It is through this opening that the rail is suspended. Figure B1 and B2 show this hatch in the closed and opened position, respectively.

The operator opens the hatch by pushing upward. There is a small pneumatic cylinder that maintains the hatch in either the open or closed position. The operator then proceeds to install the rail. He must first pull out the retaining pin that secures the device to the side wall of the vehicle. The rail can now be moved into location. The forward end is free while the rear end is suspended from the channel in the vehicle roof. This system, similar to that utilized for positioning the section of rail that attaches to the Hangrail, can be seen in Figure B3. The operator secures the forward section of the rail to a spring clip immediately inside the vehicle and secures the other end with a spring hook over a pin in the channel. The rail can be put into position in approximately one minute. When the rail is secured in position the operator releases the constraining devices on a chair and pushes the top of the hanger into the rail. The suspension of the rail forms a load-dependent friction brake. On reaching the end of the rail (which is turned somewhat upward) the passenger is lowered at a predetermined speed, irrespective of weight. The bus must be operating for the emergency exit system to function as it operates off the vehicle's pneumatic system. The descent of the rail is gradual and as soon as the chair touches the ground it can be pushed forward and away from the vehicle. The rail ascends into the normal position and another passenger can be pushed into the exit position. Figures B4 and B5 show two stages in the descent of the rail. As can be seen from those photographs it is not necessary to maintain manual contact with the passenger - having started the descent the operator can attend to readying the next passenger for exiting the vehicle while an assistant pushes the passenger away from the rail upon reaching ground level. The system is again shown in Figure B6, being utilized in this case with an adapter hanger and conventional chairs. The emergency exit system can be utilized with the exit

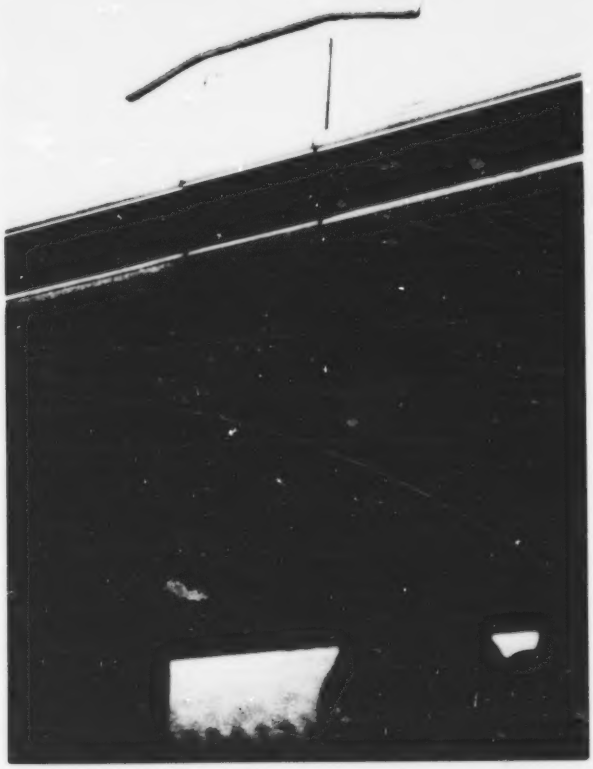
door on either side of the bus. Thus all three doors of the vehicle can be used by passengers for exiting the vehicle, the front door with the Hangrail System and either of the two rear doors with the emergency system. Although it is referred to as the emergency system it should be made clear that this emergency exit procedure is so comfortable that it can also be used for normal deboarding.

The emergency exit system still takes a certain amount of time to operate but it is considerably quicker to implement than the Hangrail System. However, the Hangrail System is much quicker than any conventional wheelchair lift. The emergency system is probably the fastest means available on any vehicle by which disabled persons can safely exit.

The sensation experienced when exiting from the vehicle by means of the emergency exit system is in no way disconcerting. The descent is gradual. The author, when trying the system for the first time, did so with his eyes closed. He was not aware of any sensation of swing or downward movement and was surprised when the special mobile seat made contact with the ground. The system is safe and efficient and permits rapid egress from the vehicle with no discomfort experienced by the passengers.

B1

Figure B1
Emergency Exist System
Hatch Above Rear Door - Closed



B2

Figure B2
Emergency Exit
System Hatch - Open

Figure B3
Operator Positioning
Emergency Exit Rail

Figure B4
Passenger Exiting
Vehicle By Emergency
Exit System

Figure B5
Passenger Exiting
Vehicle By Emergency
Exit System

Figure B6
Wheelchair With
Converter Hanger
Using Emergency
Exit System

# APPENDIX C
# OPERATIONAL PROCEDURE: SMALL BUS SYSTEM

## APPENDIX C
## OPERATIONAL PROCEDURE: SMALL BUS SYSTEM

The access means for the small bus is a rail that can be extended out of the rear of the vehicle by activation of two hydraulic cylinders. The rail system pivots around a bar that is suspended between two main frame members. Figure C1 and 12 shows the access system in the secured position.

In order to load a passenger into the vehicle the driver parks the van, descends and opens the rear door. The driver then takes the electric hand control (this can be seen in Figure 12, on the right side of the vehicle) and depresses the switch with the arrow pointing upward. The control module is shown in Figure C2. The activation of the hydraulic rams raises the rail from the storage position. This can be seen in Figure C3. When the end of the rail is at approximately the correct height the operator releases the button and commences to push the passenger towards the rail. The end of the rail can be raised or lowered as required to accept the hanger unit. When the hanger unit has been pushed into the rail (Figure C4) the operator continues to raise the rail, by pressing the switch on the control module. At the top position a cut-off switch is activated. The passenger is now suspended from the rail outside the rear door of the vehicle. See Figure C5. The operator now pushes the wheelchair forward into the vehicles, as shown in Figure C6. This operation is again shown in Figures C7 and C8.

When the wheelchair passenger has been pushed into the vehicle the chair must be correctly positioned, and secured in the desired location. The bottom locking pins are secured first. These pins extend from the upright frame members of the mobile chair or the adapter hanger. When the chair is correctly positioned over the perforated metal strip set into the vehicle floor the operator pushes down on the off-centre lever and extends the locking pins. The pins remain in the extended position due to the off-centre lever action. The bottom securement system is shown in Figure C9. The lateral locking strips in the vehicle floor can be seen in Figure C10. To secure the upper portion of the chair the operator slides the stanchion upwards, positions the end beneath a hole in the perforated strip in the vehicle roof, and then locks the pin by lifting upward on the lever and turning it to the right. Figure C11 shows the stanchion in the lowered position - the bottom of it can

be seen to the right of Figure C10. Figure C12 shows the operator having positioned the pin in the hole in the perforated strip. The lever in the secure position is shown in Figure C13. A certain effort is required to secure this lever in this position due to the strength of the spring located inside the stanchion. A chair in the secure position is shown in Figure C14.

The process for taking passengers out of the small vehicle is precisely the reverse of the loading sequence. The vehicle is stopped and the rail device is correctly positioned. Note that for activation of the device the vehicle engine must be left running and the red toggle switch on the instrument panel must be pulled out. This switch (Freigabe Hebevorrichtung) must be in the extended position for the hand held module to operate the lift device. See Figure C15. Following the release of the lower and upper securement devices the operator positions the chair such that the hanger can be pushed into the rail. The passenger generally descends from the vehicle facing outward however this can equally as well be accomplished by simply pushing the wheelchair backward and the hanger into the rail, in which case the passenger remains facing forward, to the vehicle interior. When the chair hanger is in the rail and has been pushed out to the extent possible the operator depresses the switch with the downward pointing arrow. The rail device descends and when the wheels of the wheelchair or special mobile seat touch the ground the device cuts out and the chair can be pushed out of the end of the rail.

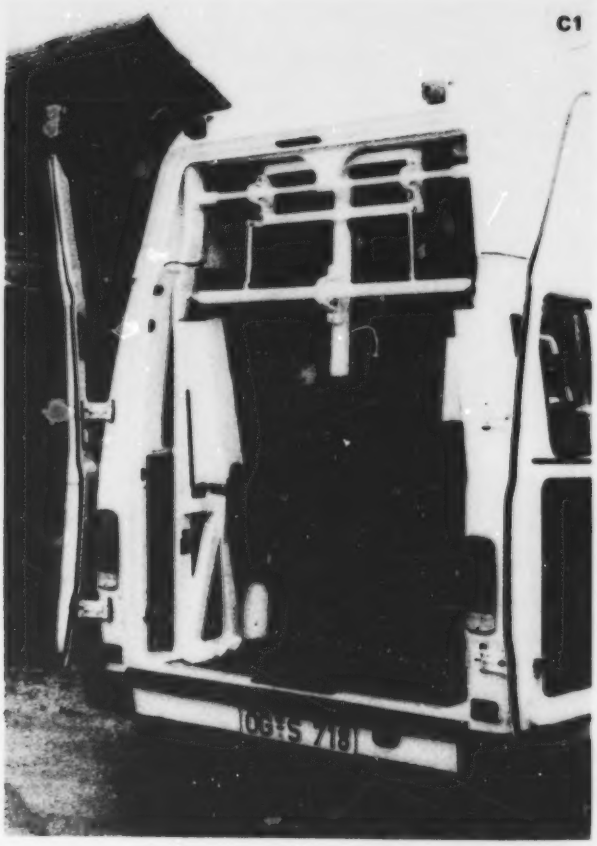



**Figure C1**
**Rear of Vehicle Showing**
**Rail In Stored Position**

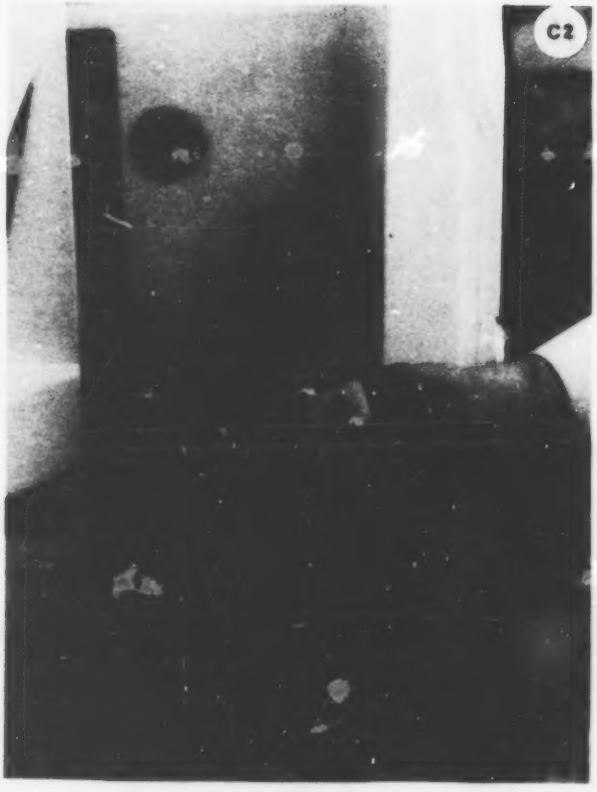



**Figure C2**
**Hand Held Control Module**

Figure C3
Operator Raising Rail
From Stored Position
For Use

Figure C4
Operator Pushing
Hanger Unit Into
Rail

**Figure C5**
**Rail Is Raised Prior**
**To Passenger Entering Vehicle**

**Figure C6**
**Operator Manoeuvring**
**Passenger Into Vehicle**

**Figure C7**
**Operator Manoeuvring**
**Passenger Into Vehicle**

**Figure C8**
**Operator Manoeuvring**
**Passenger Into Vehicle**

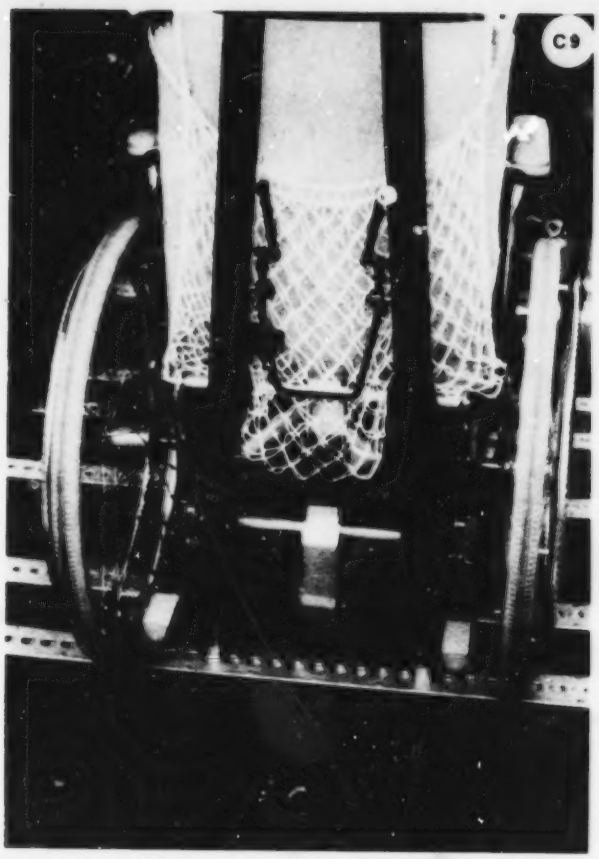



Figure C9
Lower Securement System

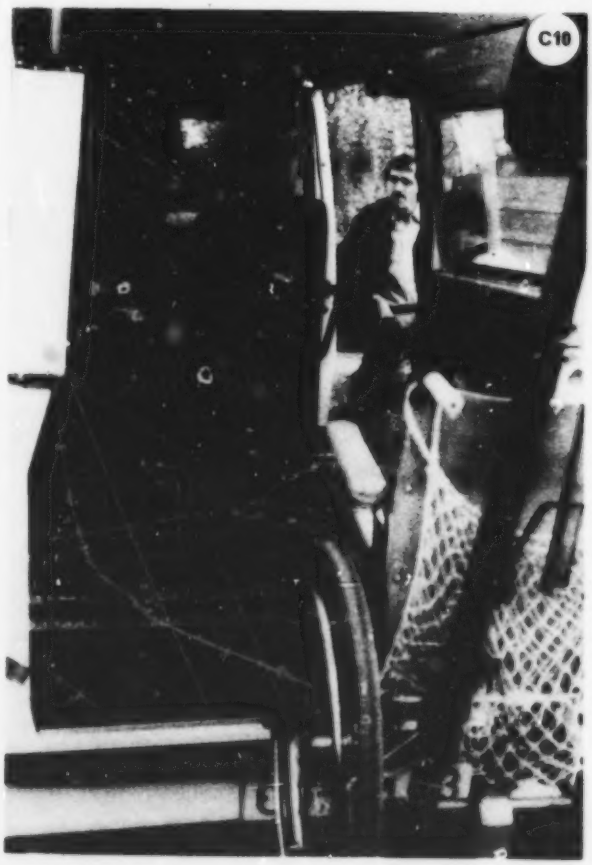



Figure C10
Inside Of Vehicle Showing
Lateral Locking Strips

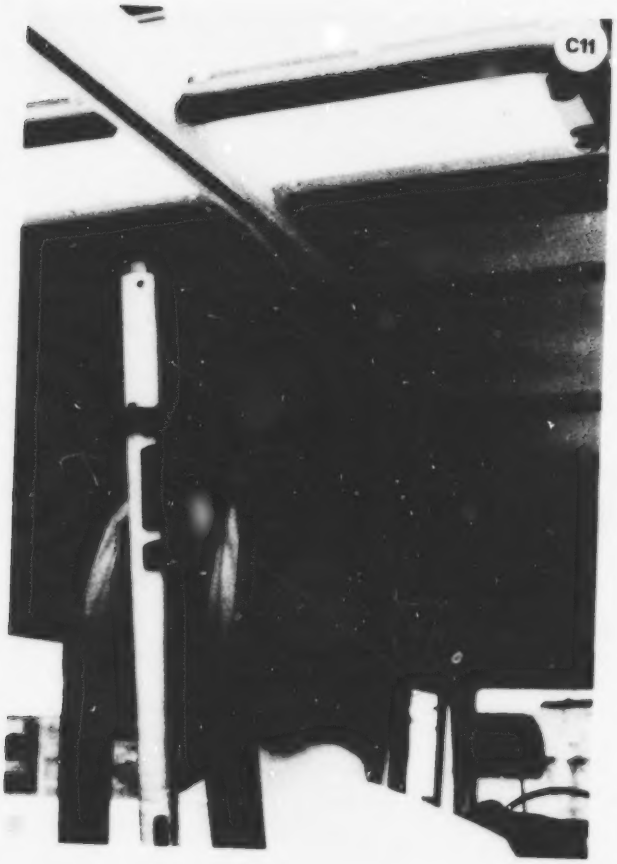



Figure C11
Upper Securement System -
Stanchion In Lowered Position

C12

Figure C12
Operator Securing Upper
Locking System

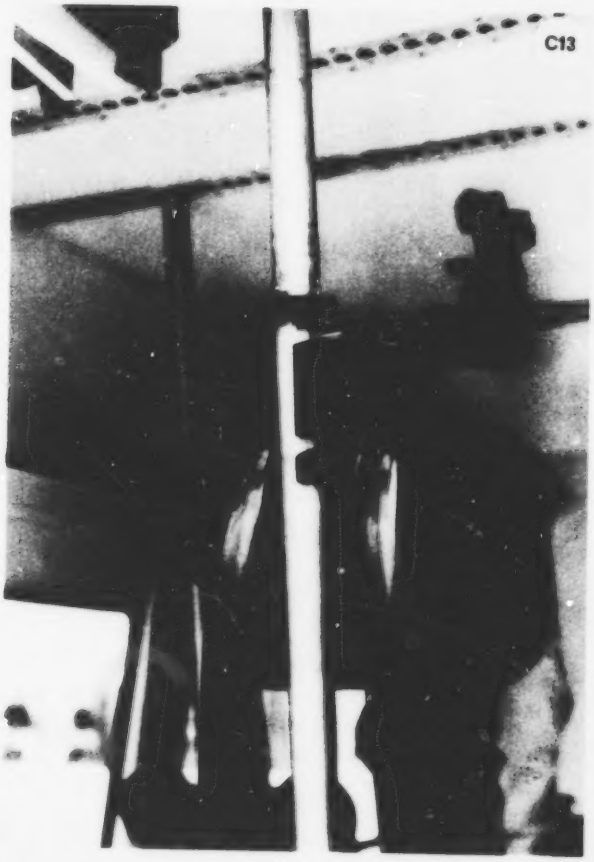



Figure C13
Locking Lever In
Secure Position

Figure C14
Special Mobile Seat
In Secure Position

**Figure C15**
**Master Control**
**Switch On**
**Instrument Panel**

# APPENDIX D

## ALTERNATIVE SEATING - SMALL BUS

## APPENDIX D
## ALTERNATIVE SEATING - SMALL BUS

The ASB in Achern have some removable bench seats that can rapidly be installed or removed. Three rows of bench seats can be accommodated in the vehicle. The full width rear seat and the narrower seat immediately in front of it can be seen in Figure D1. The seats are secured by means of four pins that extend into two rows of the perforated strips on the vehicle floor. A seat can be seen in Figure D2 secured in place. The pins that extend into the perforated strip have a groove in them. By means of a quarter turn of a centre shaft the distance between each pair of pins is increased. The pins are forced outwards from the central shaft and the groove in the pin locks onto the perforated strip. This locking system is shown diagramatically on the following page.

The same securement system can be used for individual seats within the vehicle. The main components of the system, the perforated strip and the securement panel with the two pins extending, are shown in Figure D3. The system is shown in place in Figure D4. Note the lever which controls the location of the pins and hence locks or unlocks the seat in place. A view from the underside of the strip, with the pins locked in position, is shown in Figure D5.

One of the advantages of having individual seats within the vehicle, especially ones that are readily removed, is that custom built seats can be used. To this time FFG has produced two seat types for use with the individual chair. The original design is shown in Figure D6 and the more recent model in Figure D7. Figure D8 shows the basic seat frame assembly to which the seat itself can be attached in a matter of ten or fifteen seconds.

In the rear of Figure D8 can be seen some specialized seat forms that are being used as the basis of special seats. This system permits chair seats to be made for passengers with special requirements or of a particular size (such as young children). The passenger might own the seat and for the purpose of transportation use the seat frame owned by the person or company that owns the vehicle.

## Locking System for Removable Seats

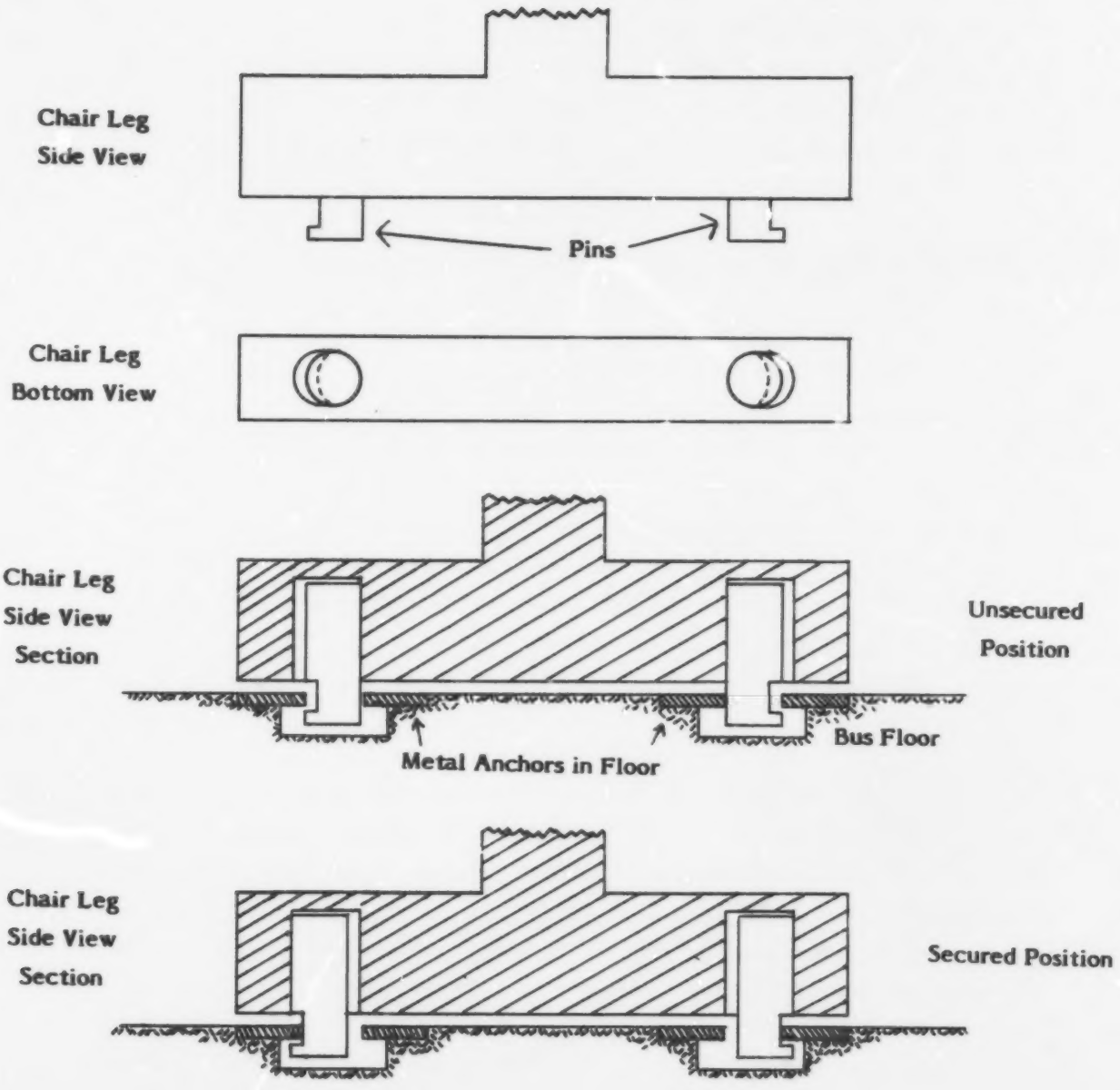


Figure D1
Alternative Bench
Seating

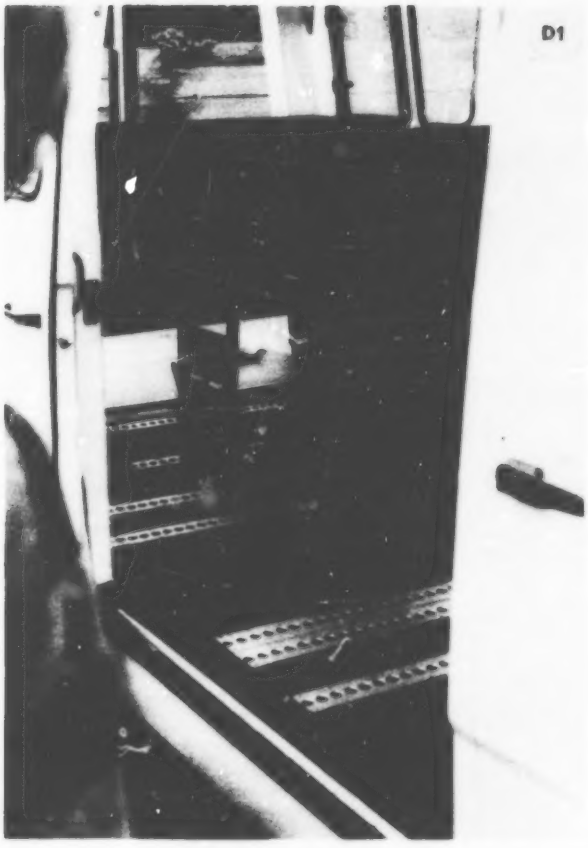
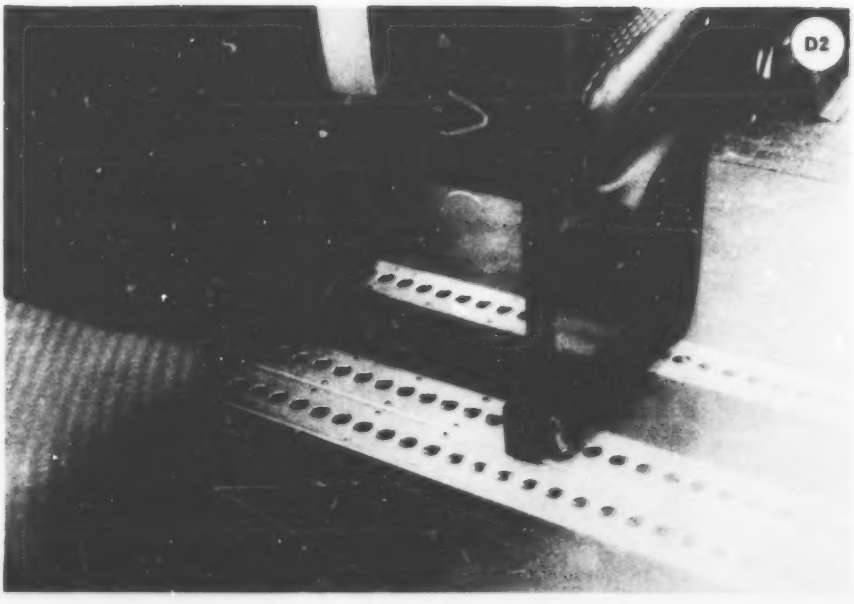



Figure D2
Removable Seat
In Secured Position



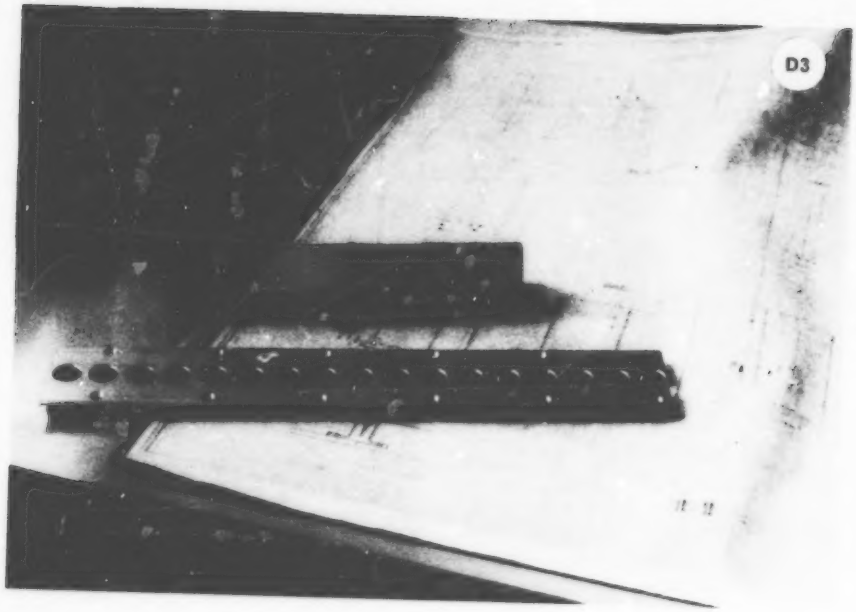



Figure D3
Securement Panel And Perforated Locking Strip

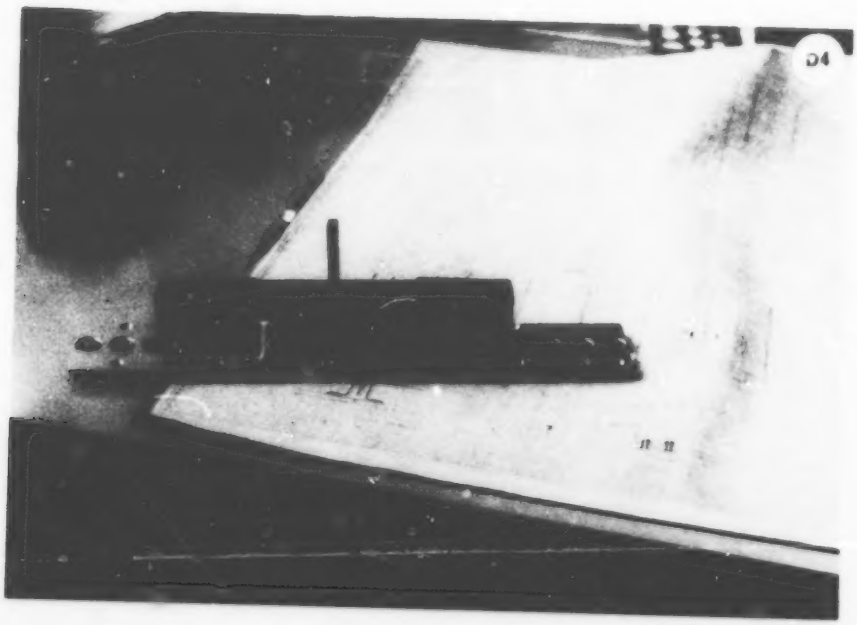



Figure D4
Securement System Components Fitted Together

Figure D5
View From Underside
Of Securement Strip,
With Locking Pins

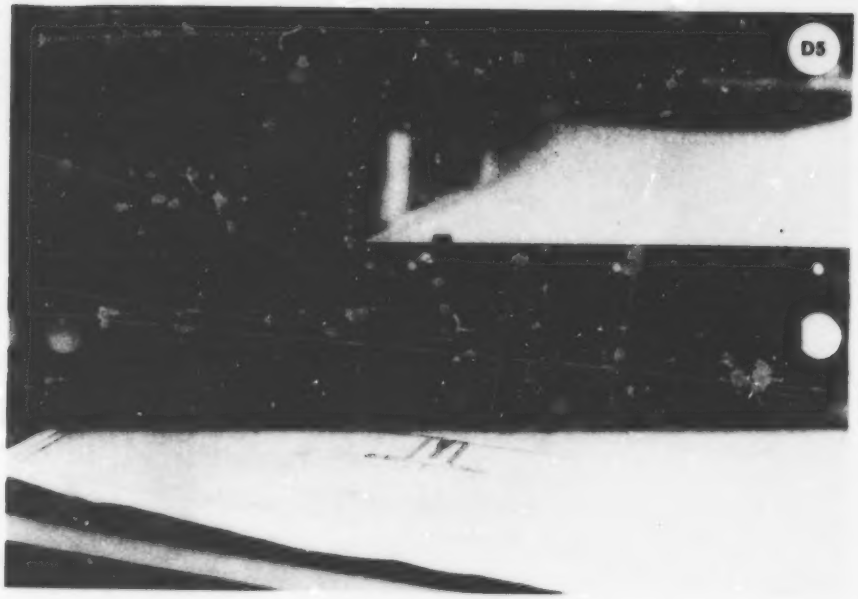
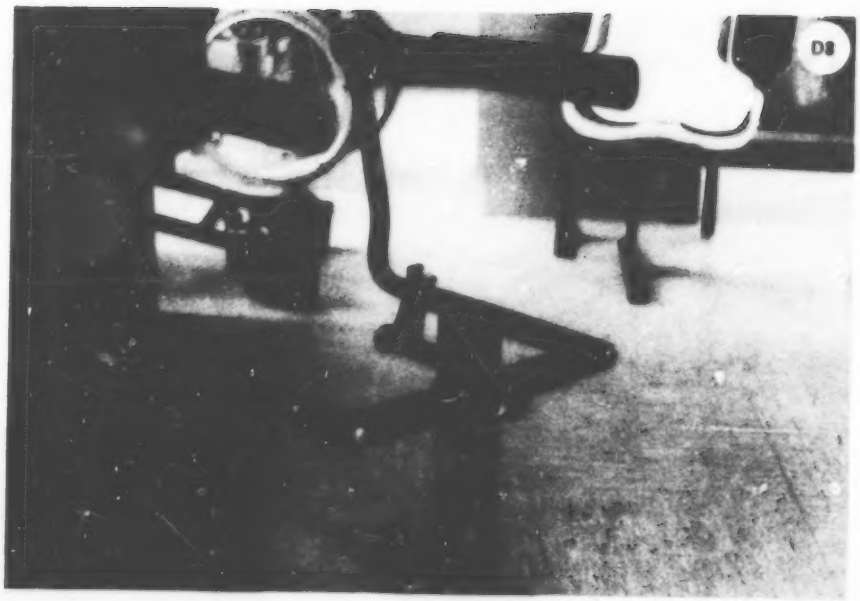



Figure D6
Removable Single Seat;
Original Design

**Figure D7**
**Removable Single Seat;**
**Recent Design**

**Figure D8**
**Seat Frame**
**Assembly**



# APPENDIX E

# ERGONOMIC EVALUATION OF THE HANGRAIL LIFT SYSTEM (RUTENBERG DESIGN INC.)

**RUTENBERG DESIGN INC.**

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APPENDIX TO TP 6005E

ERGONOMIC EVALUATION OF THE HANGRAIL LIFT SYSTEM

Rutenberg Design Inc. would like to point out that the ergonomic evaluation of the Hangrail Lift is based only on information obtained from Mr. Kaulback and photographs which he had taken during his on-site evaluation in Germany. The accuracy of an objective human factors evaluation is therefore limited.

Rutenberg Design Inc. had proposed to undertake this evaluation directly with passengers on the bus in Germany, but the financial restrictions of the project did not allow for this opportunity.

A more effective scenario for an evaluation would have been to test actual male/female wheelchair passengers with different disabilities under various performance and weather conditions.

Bearing this in mind, our evaluation addresses four main areas:

1. Hangrail Lift System
2. Mobile Seat
3. Small Bus Rail
4. Canadian Potential

## General

While the technical approach of the systems certainly seems to be sound and quite advanced, there are a number of aspects on the ergonomic side of the system which have to be changed or can be improved upon.

One of the most common questions is: Why is this long rail on the side of the bus necessary and why can't an approach be used such as the emergency direct rail route?

The side rail does not only require a substantial technical adaptation to any bus, but it also lengthens the boarding time and might make the passenger feel uneasy, as previously mentioned by the author in terms of 'cargo handling'. Any system that reduces timespans when suspending a passenger has a psychological advantage for the user.

The manufacturer made great efforts to design many components safe, functional, and aesthetically attractive to the user and our evaluation should be considered constructive in order to improve in this direction.

## 1. Hangrail Lift System

Assuming that only one operator/driver is assisting in boarding and deboarding, each chair or passenger has to be fed one by one into the rail. Measuring the rail height with a stick by the operator seems cumbersome and could possibly be improved. Why not have some coloured marks as a reference on the side of the bus? See Figure E1.

Setting up the emergency egress rail requires a substantial amount of physical effort by the operator. Working with stretched arms over head can only be done for a short time because neck and arm muscles in this position tire quickly.

This work is probably very difficult for elderly and female drivers. To a lesser degree physical effort is also required to position the interior curved rail. See Figure E2, E3 and E4.

If only one operator assists all passengers, he/she has to accompany each passenger to each seat or chair up the rail, push it on to the bus floor, disengage the seat, push it to its final place, secure and lock it, and return with an empty seat. How much time for this complete sequence multiplied by 20 passengers?

Pushing a passenger onto the bus floor level again is easy for a healthy young male. How much force is actually required for a passenger weighing 90-100 kilograms, which is often the case with people spending most of their time in a wheelchair? The handle rings on top of the backrest work when both driver and passenger are on the same level.

But when the chair is changing from the side rail to the interior curved rail, the operator's eye level is close to the passenger's knee level which could be embarrassing in a male/female situation. At the same time, in this position, there are no handlebars to push on at a comfortable and effective height for the arms. See Figure E5.

The curved top hanger of the chair frame also seems to be very close to the passenger's head support. What if somebody with crutches is standing up or switching to another chair?

According to the on-site evaluation, there is little or no swaying of the chair going up or down the rail; is this also true in strong winds?

Provision of a canopy which could be pulled out at the same time as the suspended rail should be considered. If it is raining, an empty seat will be soaking wet by the time it comes down the rail to be used. An unprotected passenger will also be exposed for about 20 seconds; enough time to get wet.

## 2. Mobile Seat

As pointed out in the main report, the mobile seat currently used has some disadvantages in that it requires a person to assist each chair at the beginning and the end of each trip. Large wheels can be attached to the new Innovint chair which , if adopted, provides greater freedom to the passenger.

Some wheelchair users can transfer quite easily from their chair, as long as the other chair is stable and strong enough to support their weight. The question here is whether the armrest and the geometry of the mobile seat make transferring easy and safe.

The footrest has no guardrail on its sides which is very important for people who have no control of their feet or legs. The seat width seems to be enough for a "standard" adult. Could an obese passenger use this seat?

The head support, back support, and seat are designed with standard ergonomics in mind. Unfortunately, a cut-off type armrest is always a cause for trouble when getting into a chair for pockets to get ripped. The handle rings at the top of the backrest are a good idea. Why not provide two more at armrest level for use when pushing the seat into the curved rail? See Figure E6 and E7.

The lap belt with its wider profile is good to provide additional support and to spread the load over a larger area, but is dangerous in collisions and severe braking. Tests with tie-down systems have shown that three-point belt systems provide better protection. (TP 3057E, "Multi-Modal Wheelchair Restraint System", U. Rutenberg, 1981.) The seat is well secured, but the passenger is not secured that well. See Figure E8.

No indication is given as to how the hanger system is adapted to electric wheelchairs. The weight and storage of this hanger are important factors as well, and handling and space requirements have to be determined.

### 3. Small Bus Rail

The small bus rail or "elephant trunk" seems a more direct way of boarding/deboarding wheelchair passengers. Total boarding time is approximately 30 seconds. It is a more appropriate way of entering a vehicle than riding along the side first. Although rear-end loading has shown some problems, e.g., for the next car to be parked too close, or for a rear-end collision to render the mechanism useless. The solution is, nevertheless, more flexible than an elevating platform and extremely realistic when considering it as an alternative method of doorway boarding/deboarding on a larger bus. The side mounted hydraulics and the drooping trunk configuration can be modified to work from the roof and to leave the doorway clear when system is not in use.

For the mobile seat and the wheelchair, essentially the same comments apply as before.

Pushing the passenger from his/her raised position horizontally onto the vehicle floor seems to be easier for two reasons:

1. The vehicle floor is lower and the weight more in line with the operator's arms.

2. The rail design itself helps to roll off the chair too. See Figure E10.

Some questions remain for when the vehicle is parked uphill or downhill on a steep inclination. Physical effort to push or to restrain the chair coming off the rail might be substantial if the "trunk" angle does not automatically adjust to such inclines.

Operation of the securement levers on the hanger appears to be on the heavy side. See Figure E11.

A good feature is the extra light, unfortunately, it is mounted in the wrong place. Where it is now positioned it shines directly into the passenger's face. A lower point, e.g., from knee level down, would be more helpful, since the floor is the most important reference for the loading of the wheelchair in darkness. See Figure E12.

The hand control unit is of compact design, good colour application for safety and visibility, and clear indications for up and down movements. See Figures E13 and E14.

The end of the trunk is reasonably sharp and could cause injuries, especially when positioned at the operator's head height. It is suggested that the end be protected with a rubber covered 25 cm ring in a fluorescent colour to prevent accidents in daytime and low light. See Figure E15.

**4. Canadian Potential**

In 1979, an overhead design lift of similar nature was proposed to VIA Rail Canada Inc. Apparently, potential passengers objected to the "suspended" boarding method and felt helpless and exposed. For many people to have their feet on the ground or on some substantial material (e.g. platform) still signifies more safety. This is not to say that this is the same case here, but some caution should be used when working against basic feelings and traditional habits.

The Hangrail system requires almost a sheltered loading and elevating position when heavy winds, snowfall or rain are prevalent. The loading doors should be at least partially closed by a curtain during the winter months to protect the boarded passengers inside from long, cold air exposure.*

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* Reference: "Design Concept for Access of Special Need Travellers to an Articulated Bus" - Transport Canada Report No. TP 4403 E, U. Rutenberg, M. Barber, 1983.

Looking at the "trunk" system, passenger loading from the sidewalk is also still prevalent in Canada since during the winter, snowbanks and drifts make it often impossible to get to the road in the first place. Parking the rear of the vehicle towards the sidewalk as an alternative to loading from the roadway would also be awkward, since the operator would have to push the wheelchair through the accumulated snow at curb edge.

During the winter months, passengers in Canada wear heavy clothing. The mobile seats are too narrow to allow for this.

The time required to attach the hangers to wheelchairs is an important factor. Salt-covered frames, tires, snow and slush have to be dealt with.

Human factors of both the driver and the passenger contribute extensively to the acceptance of the system and to its effectiveness. They are as important as the technical performance and go hand in hand with the quality and safety of the complete system.

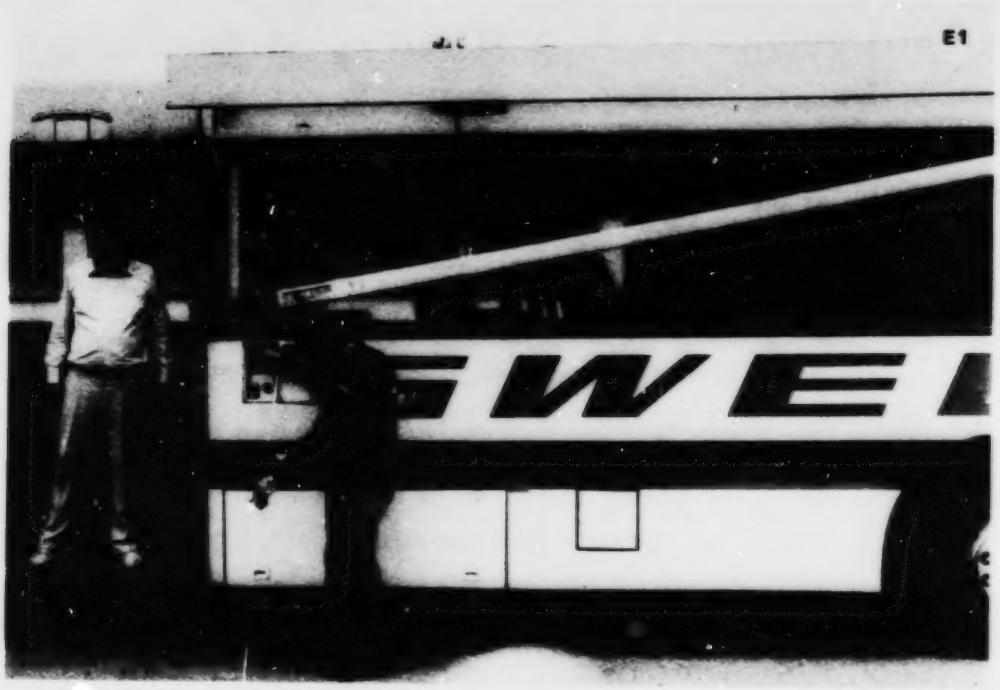


**Figure E1**
**Measuring Hangrail Height**

**Figure E2**
**Positioning Emergency Egress Rail**

**Figure E3**
**Positioning Interior Curved Rail**

**Figure E4**
**Positioning Interior Curved Rail**

**Figure E5**
**Operator Pushing Passenger**
**Into Curved Rail Section**

**Figure E6**
**Special Seat, Showing Back And Headrest**

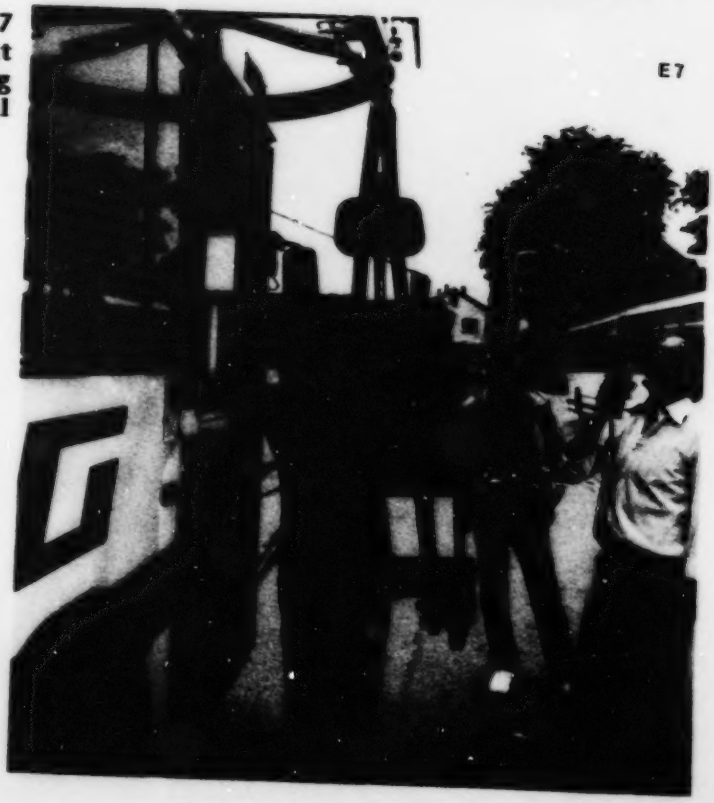


**Figure E7**
**Special Seat Descending Hangrail**

**Figure E8**
**Use of Lap Belt**

Figure E9
Securing Special
Seat With Upper
Securement Device

Figure E10
Operator Pushing
Passenger Into
Small Bus

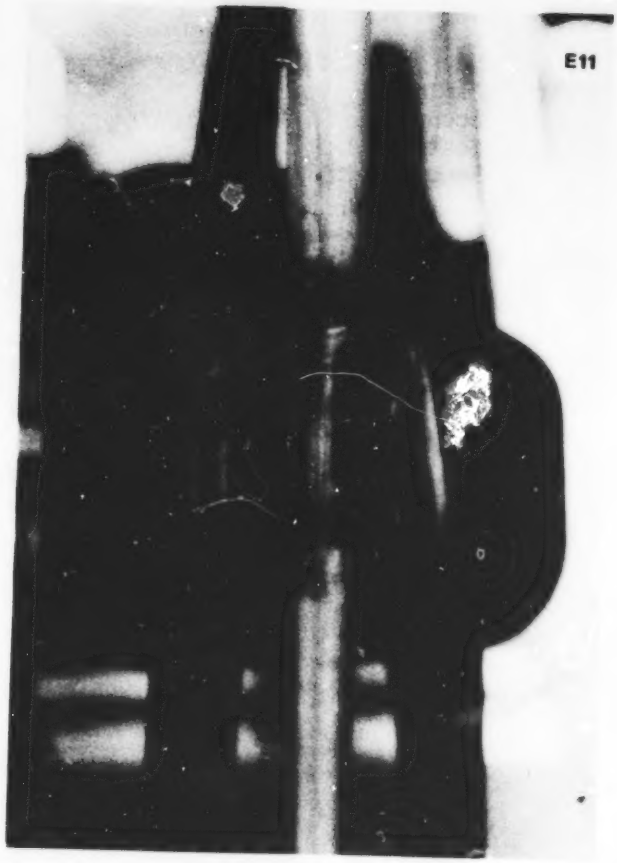


**Figure E11**
**Upper Securement**
**Lever, Special Seat**

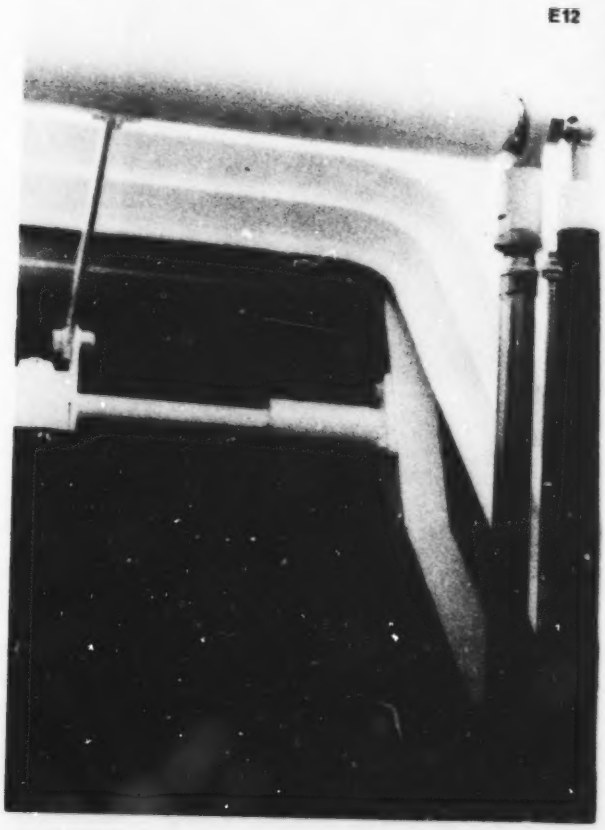


**Figure E12**
**Position of Light**
**On Small Bus**

Figure E13
Hand Control
Unit, Small Bus

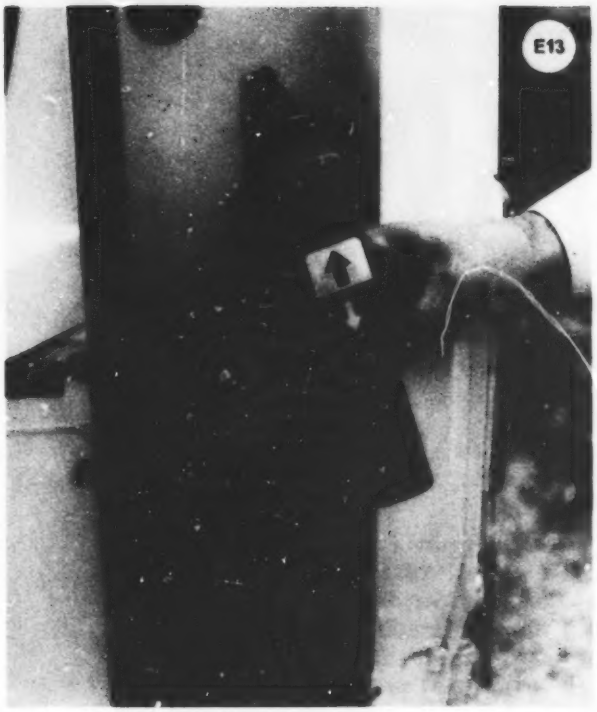


Figure E14
Operator With
Hand Control
Unit, Small Bus

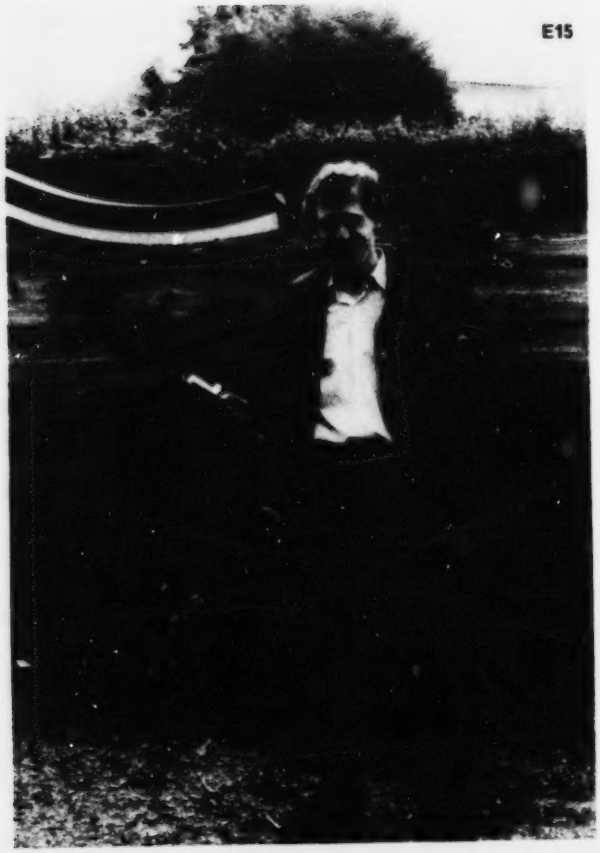


**Figure E15**
**Relative Position Of Operator And End of Loading System Rail**